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ORIGINAL ARTICLES.

I.—Note on the Sedimentary Rocks of Singapore.

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(Plate XI.)

UNTIL Mr. R. B. Newton described certain fossils from Singapore found by the writer and Dr. Hanitsch of the Raffles Library and Museum,[1] very little was known of the geology of this island, which is the nearest of the British Malayan possessions to those parts of the Netherlands Indies that have been so ably described by Verbeek, Fennema,[2] Molengraaf, Wing Easton, Martin, and others. This proximity to the islands of the archipelago renders the study of the geology of Singapore doubly interesting, since here may be expected data that will eventually assist materially in connecting the geology of the Malay Peninsula with that of the Malay Archipelago, and more particularly with that of Borneo. The object of the present paper is to show that the sedimentary beds of Singapore may be referred to one of the series of rocks which enter into the structure of the Federated Malay States.

At the time of the publication of the writer's "Report of Progress,"[3] a few opportunities of collecting notes in Singapore had been obtained, and a similarity between the sedimentary rocks and the Tembeling Series of Pahang, the main outcrop of which is on the same line of strike as the Singapore rocks, had been noticed.[4] A glance at the accompanying sketch-map (Plate XI) will show, however, that between Pahang and Singapore there intervenes the large native State of Johore, the interior of which is unbroken ground to geologists; and it was felt

[1] "Fossils from Singapore": Geol. Mag., 1906, pp. 487–496. A list of the early literature dealing with Singapore will be found in Mr. R. B. Newton's "Notes on Literature bearing upon the Geology of the Malay Peninsula," etc., Geol. Mag., 1901, pp. 128–134. The subject does not require further notice here.

[2] "Geologist's Report of Progress," September, 1902–January, 1907. Government Press, Kuala-Lumpur. A table showing the results of the Geologist's work is reproduced in Geol. Mag., 1907, p. 566.

[3] Geol. Mag., 1907, p. 567.

that under the circumstances it would be unsafe to assume an extension of the Tembeling Series in Singapore until more definite evidence was forthcoming.

The Tembeling Series consists of shale, sandstone, and conglomerate. The shales are sometimes deep red, sometimes grey; while the sandstone and conglomerate are remarkable for containing derived fragments of chert, and sometimes of black carbonaceous shale also. In Singapore the sedimentary rocks consist chiefly of fine sandstone and deep red and grey shales.

Prior to the discovery of the fossils described by Mr. Newton only a little coarse sandstone had been seen by the writer in Singapore, and it seemed essential to prove the presence of chert pebbles in either sandstone or conglomerate before including the Singapore rocks in the Tembeling Series.

Early in 1907 an opportunity presented itself of devoting several days to a further examination of the Singapore beds, with the result that the presence of chert pebbles was proved in both sandstone and conglomerate. The best sections were found at the west end of Blakang Mati, a fortified island guarding Singapore Harbour. Access to these sections was kindly permitted by the military authorities. The west end of Blakang Mati is composed of red and grey shales, sandstone and conglomerate. The beds are vertical. The general strike is N.W.–S.E. There are several bands of fine conglomerate, all showing chert pebbles; and near a point marked "Chupa Rock" on the 1904 map of Singapore, by the Colonial Engineer and the Surveyor General, a band of coarse conglomerate is exposed in a deep cleft between a large isolated mass of rock and the cliff. This also contains chert pebbles and other pebbles to be noted later.

Again, in the grounds of the municipal filter beds, behind Government House, grey and red shales and sandstone are exposed. Here also fresh specimens show that the sandstone contains fragments of chert.

In the writer's Report of Progress it is assumed that the presence of the chert pebbles in the conglomerate of the Tembeling Series in Pahang shows an unconformity between the Tembeling Series and the Raub and the Chert Series. It was pointed out, however, in this report, that pebbles of the Pahang Volcanic Series, which one would expect in the conglomerate also, had not been found, but that little time had been spent in searching for them. In the "Chupa Rock" section on Blakang Mati several pebbles of pale-green partially decomposed lava were found (probably andesite or dacite), agreeing with some of the Pahang rocks; and a subsequent comparison of these pebbles with the material of specimens of sandstone from Pahang showed that small, soft, pale-green fragments in the sandstone are probably decomposed lava also. The pebbles in the Singapore conglomerate were well enough preserved for microscopic examination.

It may be noted here that Pahang Volcanic Series rocks are known to occur in Singapore as rough boulders which are probably hard 'cores' left from beds now weathered away. The writer has not yet seen any such rocks in Singapore clearly *in situ*.

One large chert pebble from the "Chupa Rock" section was cut for microscopic examination. The slides show abundant obscure

organic remains: but it is remarkable that whereas in other cases radiolaria are commonly recognizable, in these slides no structure was observed that could be definitely referred to this group.

While the writer feels no hesitation now in regarding the Singapore rocks as an extension of the Pahang Tembeling Series, he nevertheless thinks a word is necessary regarding the palæontological evidence in order to meet a possible objection. Mr. R. B. Newton, to whom the writer is greatly indebted for assistance in this direction, when describing the fossils found by Mr. Bellamy near Kuala Lipis, in Pahang, as Rhætic, emphasized the fact that *Myophoria* is exclusively Triassic.[1] The same author, referring to *Estheriella radiata* (Salinas), var. *multilineata*,[2] found in Tembeling Series rocks in Perak, and described by Professor Rupert Jones, also remarks that the genus *Estheriella*, "so far as can be ascertained, is only known to have existed in Triassic times"; while, writing of the Singapore fossils, Mr. Newton says that the beds containing them "may be of Middle Jurassic age, and about the horizon of the Inferior Oolite of England or the so-called Bajocian of Continental geologists."[4] The presence of *Goniomya* and *Podozamites* leads the author to this conclusion, but he remarks that *Goniomya* has also been found in Palæozoic rocks, although exceedingly rare;[5] and the range of *Podozamites* in Europe is described by Nicholson & Lydekker as "from the Rhætic into the Lower Cretaceous."[6]

It is far from the writer's purpose to suggest any amendment to these remarks on the fossils he had sent to England. His object is to show that the palæontological evidence does not make it necessary either to separate the Singapore and Pahang beds, or to assume that a series of estuarine deposits of unknown thickness covers at least part of the Rhætic, the whole of the Lias, and part of the Inferior Oolite.

Mr. Newton has suggested that the Singapore rocks may be an extension of the Upper Gondwana of India, and the writer has made a similar suggestion regarding the Tembeling Series. It will be very interesting in this connection to see the result of the examination of the Shan States Rhætic fossils collected by Mr. De la Touche.

II.—Sedgwick Museum Notes: New Fossils from Girvan.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XII.)

Ischadites Konigi, Murchison.

IN the list of fossils from the Silurian rocks of the South of Scotland in the collections of the Geological Survey the two species of *Ischadites*, *I. antiquus*, Salter, and *I. Konigi*, Murchison, are entered

[1] "Marine Triassic Lamellibranchs from the Malay Peninsula": Proc. Malac. Soc., vol. iv, part 3, October, 1900, p. 130.
[2] Geol. Mag., 1905, p. 49.
[3] Ibid., pp. 50–52.
[4] Ibid., 1906, p. 488.
[5] Ibid., pp. 487–8.
[6] "A Manual of Palæontology," vol. ii (1889), p. 1529.
[7] Mem. Geol. Surv., Silurian Rocks of Britain, vol. i, Scotland, 1899, p. 668.

as occurring in the Llandovery rocks, while a third unnamed species is recorded from the Caradoc. In the list of fossils prepared by Mrs. Gray from the collection made by her from the Silurian rocks of the Girvan district,[1] *I. Konigi* is recorded from the Llandeilo beds of Balclatchie, *I. antiquus* from the Upper Llandovery of Penkill and the Middle Llandovery of Woodland Point, and *I.* sp. from the Middle Llandovery of Newlands. Nicholson & Etheridge[2] mentioned only two specimens of *Ischadites*, one from Balclatchie and the other from Penkill; both were referred to under the name *I. Konigi*, but it was remarked that one of them appeared to possess more the characters of *I. antiquus*. The first discovery of *I. Konigi* in the Girvan area was made by Mr. Robert Gray, and was noticed by Professor J. Young[3] in 1868, and in 1876 the same author recorded it from Penkill in his "Catalogue of Western Scottish Fossils," p. 13. Dr. Hinde[4] cites both the localities, Balclatchie and Penkill, for the occurrence of *I. Konigi*, but he regards the species *I. antiquus* as indistinguishable from it. The only other British species mentioned by this author (*loc. cit.*) is *I. Lindstromi*, Hinde.

The specimens submitted to me by Mrs. Gray comprise portions of four individuals with the external impression of one of them. All come from the Upper Llandovery of Penkill, and are in a poor state of preservation. The slightly concave base is seen in two of them, the smaller specimen measuring only 14 mm. in diameter and the larger one 35 mm.; the central 5–6 series of summit plates are arranged in fairly definite concentric circles. In another of the specimens the horizontal rays of the spicules number only three, the proximal ray being absent, as Hinde has explained is sometimes the case.[5]

There is only one specimen from Balclatchie which Mrs. Gray has sent me, and this closely agrees with Salter's *I. antiquus*[6] from the Llandeilo of Garn Arenig, Wales. The four horizontal rays of the spicules are well seen on the narrow transversely rhomboid summit plates, which also seem rather more numerous than in the Penkill examples of *I. Konigi*. Only the basal portion of the sponge is preserved, and the central portion seems to have been somewhat elevated into a short obtuse boss; but the whole organism has been crushed and more or less flattened out, thus increasing the apparent diameter, which measures about 58 mm.

Receptaculites Grayi, sp. nov. (Pl. XII, Figs. 1, 2.)

Amongst the material which Mrs. Gray has recently sent me for determination there are several very fragmentary specimens from the Middle Llandovery of Woodland Point which must be referred to the genus *Receptaculites*, and they probably represent a new species. They consist of portions of the upper and lower surfaces, but no

[1] Mem. Geol. Surv., Silurian Rocks of Britain, vol. i, Scotland, 1899, pp. 510, 548, 686.

[2] Nicholson & Etheridge: Mon. Silur. Foss. Girvan, pt. i (1878), p. 20.

[3] Young: Proc. Nat. Hist. Soc. Glasgow, ser. i, vol. i (1869), p. 197.

[4] Hinde: Quart. Journ. Geol. Soc., vol. xl (1884), p. 855.

[5] Ibid., p. 814, pl. xxxvi, fig. 1*f*.

[6] Salter: Mem. Geol. Surv., vol. iii (1866), p. 282, fig. 4.

perfect individual occurs amongst them. Some of these fossils have a slightly convex or domed surface composed of small plates, which much resemble in appearance those described and figured by Rauff[1] as belonging to the wall of *R. orbis*, Eichwald, as preserved in a limestone pebble of Ordovician age from Wartin in Pomerania. The Girvan organism must have been elliptical or subcircular in shape, and the more or less marked convexity of the upper surface, which these plates cover, seems to be an original and natural feature and not due to distortion or pressure. The plates themselves on the upper surface are small, numerous, of regular rhomboidal shape, and of equal size, about seven plates measuring 10 mm. along their greater diameters, and about nine plates measuring also 10 mm. along their shorter diameters. The plates are fitted closely together into a pavement, as usual in the genus; the boundaries of the individual plates are not very sharply marked, being partly obscured by their ornamentation and perhaps fused to a certain extent along their edges. In one specimen there is a pore at each angle between the plates, as Hinde[2] has shown in his figures of *R. occidentalis*. Each plate is gently convex, rising slightly towards the centre, in which is a more or less indistinct small depression, from which radiate to the sides a number of short, broken, irregular, and sinuous ridges and vermiculate grooves, interspersed with or replaced by small closely-set pits and tubercles of the same size and elevation, which by their fusion seem to produce the above-mentioned ridges and grooves (Pl. XII, Fig. 1). On many of the plates only pits and tubercles are present, and no radial arrangement is noticeable. From the examination of both the natural casts and the external impressions of the same specimens which have been carefully collected by Mrs. Gray, and from the regular occurrence of these surface-features, it becomes clear that they are not due to weathering, though Rauff was in some doubt on this point in connection with his specimen of *R. orbis*. Our Girvan species differs from the latter by the less distinct character of the radial ornamentation, by the more transversely rhomboidal shape of the plates, and by their reduced overlapping.

A fragment of the lateral (lower) surface and margin of the same species comes from the same horizon and locality. It shows a few of the outer series of upper plates, apparently similar to those above described but rather larger, situated near the edge of the upper dome, and passing over into the flattened, smooth, and larger subquadrate plates of the lower surface. These plates decidedly overlap, like tiles, from above downwards, the lower overlapping angle being generally rather prominent and thickened. A shallow median depression or pit is generally noticeable on each plate, indicating the point of attachment of the vertical ray or column of the spicule. Rauff has figured closely similar plates (op. cit., t. i, fig. 10) from the upper surface of *R. Neptuni*. Occasionally traces of tubercles seem to be visible on the surface of these plates, but this is doubtful.

[1] Rauff: Abhandl. k. bayer. Akad. Wiss., Math. Phys. Kl., Bd. xvii (1892) p. 688, t. iv, figs. 2–6.

[2] Hinde, op. cit., pl. xxxvii, figs. 3*d*, 3*e*.

The plates decrease in size gradually downwards towards the base or lower pole, but the specimen is very imperfect. However, the distinction between the small convex, radially pitted plates, with depressed sutures on the upper surface, and these large, smooth, almost flat, tile-like, overlapping plates of the lower surface, is most marked, as Hinde has pointed out in *R. occidentalis*.

As for the actual shape of this sponge from Woodland Point, the evidence certainly suggests that the upper surface was domed; the base is imperfectly known, and whether it was concave like *Ischadites Königi* or convex or conical must remain at present an open question.

No British species of *Receptaculites* appears to have been described with the above characters, and the Scandinavian and Russian *R. orbis*, Eichwald,[1] from the Lower Silurian, appears to possess the nearest affinities.

The cast and impression of the specimen from the Middle Llandovery of Newlands which has been entered in Mrs. Gray's list as *Ischadites* sp. may probably belong to this same species. But it is in a poor state of preservation, and consists of a mere fragment of the upper surface. The plates are of regular rhomboidal shape, measuring about 2 mm. along their longer diameter, and 1 mm. along their shorter diameter; their surface appears to be channelled and pitted, and pores are found at their angles in the suture-lines, with 3–4 additional pores, usually smaller in size, along their sides. But the surface of the fossil is much weathered and imperfect, so that it is difficult to know which of these characters and structures are original.

Receptaculites girvanensis, sp. nov. (Pl. XII, Figs. 3–6.)

Shape crateriform, low, conical, with broad thick rounded lip and obtusely pointed base. Plates very numerous, rhomboidal to quadrate, all four sides being almost of the same length, very small near base, increasing very gradually in size from base to lip of cup, arranged in regular series of strongly curved intersecting rows in the usual "engine-turned" fashion; towards the lip the series run almost horizontally owing to the strong curvature of the rows, and the plates of successive series seem to lie in vertical rows. Lower plates near base subquadrate, with surface flattened and overlapping slightly in tile-like manner; but becoming more and more convex towards lip, where no imbrication is present, and a large pore lies in the grooves at each angle between the plates. Surface of flattened lower lateral plates smooth; surface of convex lip plates ornamented with small irregular pittings.

Dimensions.—Diameter of cup, about 47 mm.; height of ditto, about 22 mm.; size of plates on lip, 8 plates to every 10 mm.

Remarks.—One large specimen, of which the dimensions are given above, affords the principal means of diagnosing the characters of this form, but there is another smaller example broken off below the lip which has a diameter of about 20–25 mm. and a height of 9–10 mm. Both come from the Starfish Bed of Thraive Glen. The larger one is fairly well preserved, though the surface of the plates is somewhat

[1] Rauff, op. cit. supra.

weathered, and the concavity of the cup is hidden by matrix. It seems to be a new species, but the arrangement of the plates and general characters ally it to *R. occidentalis*, Salter, of the Trenton and Galena Limestones of North America, and to *R. orbis*, Eichw.,[1] from the Orthoceras Limestone of the Baltic regions.

It cannot, however, be identified with either of these species, nor with any other previously described from the British Isles, and though its characters are somewhat imperfectly known a specific designation seems necessary, and that of *R. girvanensis* is suggested.

Spongarium ardmillanense, sp. nov. (Pl. XII, Figs. 7, 8.)

Corallum subcircular, discoidal, or saucer-shaped, flattened, thin, composed of small, contiguous, low, rounded, subequal ridges, radiating to margin regularly and horizontally in one plane from small smooth central area, and increasing in number by bifurcation at a little more than half their length with a considerable amount of regularity (and by less frequent intercalation) to the number of 100–110[5] on the margin. Ridges crossed by 3–4 strong concentric wrinkles and by numerous, fine, regular, equidistant, closely-set, impressed lines. Inferior surface of corallum not visible.

Dimensions.—Major diameter, 30 mm.; minor ditto, 25 mm.; about twelve ridges to every 10 mm. round margin.

Remarks.—The counterpart of this specimen has precisely the same appearance, the disc or flattened saucer having been split regularly in one plane. Probably the base was covered with a thin epitheca, and it seems to have had a small central knob for attachment. The substance of the corallum appears to have been of a black corneous nature.

This peculiar fossil may best be referred to the genus *Spongarium*, the true affinities and zoological position of which are unknown. The species which approaches it most closely is *Sp. equistriatum*, M'Coy,[2] from the Upper Ludlow rocks; the elliptical shape and coarseness of the closely-set radiating ridges are features in common, but in the bifurcation of the ridges in our species there is an obvious difference. No British member of this genus appears to have been recorded except from the Ludlow beds. Ours comes from the Balclatchie Group of Ardmillan.

Annelidan Tube (?). (Pl. XII, Figs. 9, 10.

Body forming a regularly cylindrical (?), straight, jointed tube, composed of a number (+ 15) of thin, calcareous, nearly flat rings of regular and equal size, successively overlapping to a slight extent those behind, and somewhat thickened towards the overlapping (posterior) edge. Each ring has a length approximately equal to one-third the diameter of the tube, and is marked by fine regular longitudinal plications, causing a weak serration of the posterior edge; a very delicate longitudinal striation is also present. Length of rings, 1·5–4·6. Diameter of tube, about 5 mm.

[1] Hinde, op. cit., p. 842, pl. xxxviii, figs. 3, 3*a–m*.
[2] Rauff, op. cit., pp. 654–661, t. iii, figs. 7–10; t. iv, figs. 1–9.
[3] M'Coy: Brit. Pal. Foss., Woodw. Mus., 1855, p. 42, pl. 1B, figs. 15, 15*a*.

Horizon and Locality.—Drummuck Group: Thraive Glen, Girvan.

Remarks.—The three specimens in Mrs. Gray's collection are somewhat crushed and the tube is flattened, supposing it to have been originally cylindrical: and it is to crushing that we may attribute two continuous longitudinal grooves running down the side of one specimen across several rings; and possibly in another specimen a narrow flattened longitudinal ridge traversing uninterruptedly six or seven consecutive segments is also due to the same cause.

This curious jointed tubular fossil is most probably of an annelidan nature, and allied to *Cornulites* and *Conchicolites*.[1] It differs from the former by its cylindrical instead of conical shape, but agrees in the overlapping of the flat rings and longitudinal striation, as well as in its solitary habit and non-attachment to foreign objects. *Conchicolites* is gregarious, attached, and curved, with thin walls and no longitudinal striæ, but is not so markedly conical as *Cornulites*. The latter is known only from the Silurian, but *Conchicolites* is an Ordovician genus. It does not seem possible to refer it to either of these genera sens. str., though its affinities with them are suggested.

EXPLANATION OF PLATE XII.

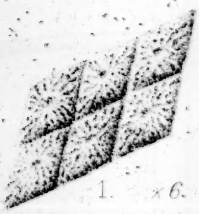
Fig. 1.—*Receptaculites Gragi*, sp. nov. Plates of upper surface, showing ornamentation. × 6.
" 2.—Ditto. Plates of lower surface. × 4.
" 3.—*Receptaculites girvanensis*, sp. nov. General view of specimen. × 1½.
" 4.—Ditto. Portion of lateral surface of same specimen, showing arrangement of plates. × 2.
" 5.—Ditto. Plates near lip of same specimen. × 8.
" 6.—Ditto. Plates near base of same specimen. × 6.
" 7.—*Spongarium ardmillanense*, sp. nov. × 1½.
" 8.—Ditto. Counterpart. × 1½.
" 9.—Annelidan tube (?). × 3.
" 10.—Ditto. Two segments. × 6.

III.—On some minor British Earthquakes of the years 1904–1907.

By Charles Davison, Sc.D., F.G.S.

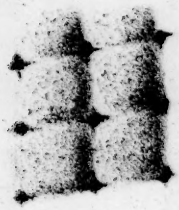
THE four years 1904–1907 were marked by the occurrence of three considerable earthquakes, one of which (the Derby earthquake of July 3rd, 1904) disturbed an area of about 25,000 square miles, another (the Doncaster earthquake of April 23rd, 1905) an area of about 17,000 square miles, while the third, the Swansea earthquake of June 27th, 1906, was felt over an area of 66,700 square miles, and, with the exception of the Hereford earthquake of 1896, was the strongest felt in this country during the last twenty years. Besides these, there were 56 others of less intensity, 9 of which originated in England; 44 in Scotland, and 3 in Wales. The total number for the nineteen years 1889–1907 is thus 214, or 50 in England, 137 in Scotland, and 27 in Wales.

[1] Nicholson: Amer. Journ. Sci., vol. iii, ser. iii (1872), p. 202.

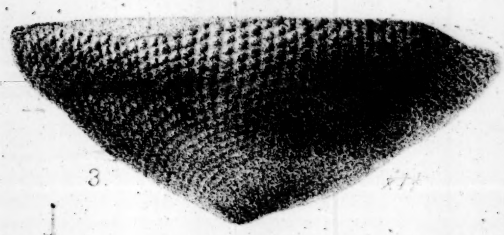


1. ×6.

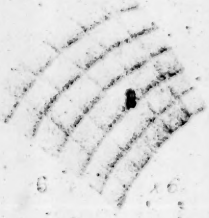
2. ×4.



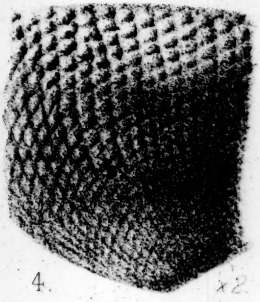
5. ×8.



3. ×1½.

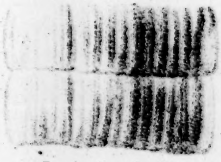


6. ×6.

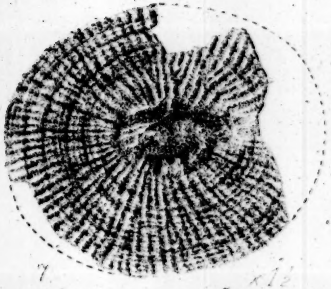


4. ×2.

9. ×2.



10. ×6.



7. ×1½.

8. ×1½.

A. H. Searle del. et lith. West, Newman imp.

Receptaculitidæ, etc. from Girvan.

List of Earthquakes.

1904.

March 3, about 1.5 p.m. Penzance.
June 21, about 5.30 a.m. Leicester.
—— 5.28 a.m. Leicester (principal earthquake).
July 3, 2.28 p.m. Derby.
—— 3.21 p.m. Derby (principal earthquake).
—— 14.8 p.m. Derby.
Sept. 18, 4.7 a.m. Dunoon (Argyll-shire).
Oct. 21, about 6.5 a.m. Beddgelert (Carnarvonshire).

1905.

Jan. 20, 1.50 a.m. St. Agnes (Cornwall).
April 23, about 1.30 a.m. Doncaster.
—— 1.37 a.m. Doncaster (principal earthquake).
—— about 4 a.m. Ochil.
July 23, 12.15 a.m. Ochil.
July 26, about 6.3 p.m. Ochil.
Sept. 21, 11.33 p.m. Ochil (principal earthquake).
Sept. 22, about 1.30 a.m. Ochil.
Sept. 25, early morning. Ochil.
Sept. 30, 9.15 p.m. Ochil.
Oct. 28, 10.53 a.m. Ochil.
Dec. 22, 9.15 p.m. Ochil.

1906.

May 7, 8.20 p.m. Fort William.
June 27, 9.45 a.m. Swansea.
June 29, 3.2 a.m. Carnarton.
July 3, 2.15 p.m. Ochil.
July 4, 3.45 p.m. Ochil.
July 7, 5.29 a.m. Ochil.
Aug. 24, 5.25 p.m. Ochil.
Aug. 27, 5.56 a.m. Derby.
Sept. 28, 12.25 p.m. Ochil.
Oct. 3, 4.32 a.m. Ochil.
Oct. 8, 7.24 a.m. Ochil.
—— 8.16 a.m. Ochil.
Oct. 12, 7.20 a.m. Ochil.
Oct. 20, 7.15 a.m. Ochil.
Oct. 24, 7.41 p.m. Ochil.
Oct. 26, 7.15 p.m. Ochil.
Oct. 30, 12.15 p.m. Ochil.
Dec. 28, 4.12 p.m. Ochil.
Dec. 29, 1.50 p.m. Ochil.
Dec. 30, about 1 a.m. Ochil.
—— 2.10 p.m. Ochil.
—— 4.15 p.m. Ochil.
Dec. 31, 1 a.m. Ochil.

1907.

Jan. 17, 1.54 p.m. Oban.
Feb. 10, 5.40 p.m. Ochil.
March 19, 7.33 p.m. Ochil.
April 7, 11.11 p.m. Ochil.
—— 11.19 p.m. Ochil.
April 8, 6.45 a.m. Ochil.
April 11, 5.30 a.m. Ochil.
—— 5.40 a.m. Ochil.
—— 6.5 a.m. Ochil.
June 14, 1.59 a.m. Ochil.
June 20, 3.56 p.m. Ochil.
July 3, 3.40 a.m. Swansea.
July 5, 9.18 p.m. Ochil.
July 21 or 28, afternoon. Ochil.
Sept. 18, about 5.30 p.m. Ochil.
Sept. 27, 8.12 a.m. Malvern.

The more important of these earthquakes have been described in the following papers:—

"The Penzance Earthquake of March 3rd, 1904": Geol. Mag., Vol. I (1904), pp. 487–490.
"The Leicester Earthquakes of August 4th, 1893, and June 21st, 1904": Quart. Journ. Geol. Soc., vol. lxi (1905), pp. 1–7.
"The Derby Earthquakes of July 3rd, 1904": ibid., pp. 8–17.
"The Doncaster Earthquake of April 23rd, 1905": ibid., vol. lxii (1906), pp. 5–12.
"The Swansea Earthquake of June 27th, 1906": ibid., vol. lxiii (1907), pp. 354–361.
"The Ochil Earthquakes of September, 1900, to April, 1907": ibid., vol. lxiii (1907), pp. 362–374.

The remaining earthquakes form the subject of the present paper. I have also added brief notices of some earthshakes in mining districts, and of doubtful or spurious earthquakes, the occurrence of which was reported in newspapers, without any subsequent statement of their artificial origin.

1. *Dunoon Earthquake: Sept. 18th, 1904.*—Time of occurrence, 4.7 a.m.; intensity, 5; centre of isoseismal 5, in lat. 55° 54·5′ N., long. 5° 10·4′ W.; number of records 79, from 28 places, and negative records from 4 places.

The disturbed area is traversed by two isoseismal lines of intensities 5 and 4. The former is 26 miles long, 15 miles wide, and about

300 square miles in area, its centre being 9 miles west of Dolgellau. The latter is 36 miles long, 21 miles wide, and 564 square miles in area, the direction of its longer axis being E. 40° N. The distance between the two curves is 2·1 miles towards the south-east and 3·7 miles towards the north-west.

The shock consisted of a continuous series of tremors, lasting on an average of 2½ seconds, and gaining in strength towards the close.

The sound was heard by all of the observers, and was compared in 38 per cent. of the records to passing waggons, etc., in 31 per cent. to thunder, in 6 to wind, in 5 to the fall of loads of stone, in 2 to the fall of a heavy body, in 17 to explosions, and in 2 per cent. to miscellaneous sounds. The beginning of the sound preceded that of the shock in 71 per cent. of the records, coincided with it in 23, and followed it in 6 per cent.; while the end of the sound preceded that of the shock in 21 per cent. of the records, coincided with it in 28, and followed it in 52 per cent. The duration of the sound was greater than that of the shock in 89 per cent. of the records, and equal to it in 11 per cent.

So far as we can judge from the seismic evidence, the mean direction of the originating fault is about E. 40° N., and its hade towards the north-west. Several of the faults laid down on the Survey map have approximately this direction, but I do not feel that the elements are determined with sufficient accuracy to justify its connection with any particular fault.

2. *Beddgelert Earthquake: October 21st*, 1904.—Time of occurrence, about 6.5 a.m.; intensity, 4; number of records 5, from 4 places.

I am indebted to Mr. E. Greenly and Mr. J. R. Dakyns for all the records of this earthquake, which seems to have been chiefly perceptible in the district lying to the south of Snowdon. The shock was felt at Blaenau Ffestiniog, Plas Gwynant, and Croesor, the last two places being respectively 3 miles north-east and 4 miles south-east of Beddgelert. The shock was accompanied by a noise somewhat like thunder at these places and also at Beddgelert. Thus the earthquake was perceptible over a district measuring at least 7 miles from east to west and 3½ miles from north to south.

3. *St. Agnes Earthquake: Jan. 20th*, 1905.—Time of occurrence, 1.50 a.m.; intensity, 5; centre of isoseismal 4, in about lat. 50° 22′ N., long. 5° 18′ W.; number of records 44, from 24 places, and negative records from 9 places. (Fig. 1.)

Most British earthquakes are connected with foci, which lie beneath the land-area of the country. A few, however, are due to displacements that are partly or entirely submarine. The epicentres of the Pembroke earthquake of August 18th, 1892, and the Carnarvon earthquake of June 19th, 1903, appear to have been in part beneath the sea. On March 3rd, 1904, a submarine earthquake occurred in the neighbourhood of Penzance, and this was followed within less than a year by another, with its epicentre on the opposite side of the Cornish peninsula, and distant not more than 22 miles from that of the Penzance earthquake.

As will be seen from the accompanying map (Fig. 1), only portions of the isoseismals 5 and 4 can be drawn, and from their form it is evident that the epicentre is situated several miles from land.

Continuing the isoseismal 4 in what appears to be its probable course, it includes an area 31 miles long, 22 miles wide, and containing about 530 square miles; the centre of the curve being about 6 miles north-west of St. Agnes, while the longer axis runs from north-east to south-west, or roughly parallel to the adjoining coastline. Too small a part of the isoseismal 5 lies on land to allow its dimensions to be even approximately determined. On the south-east side the distance between the two curves is 3 miles.

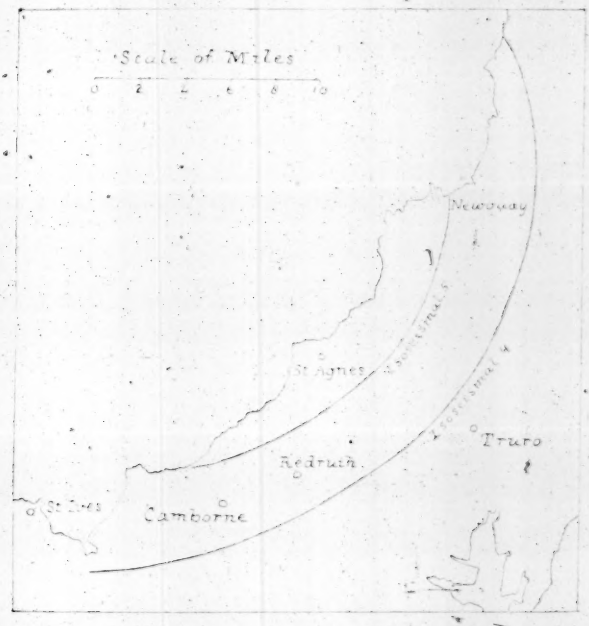


Fig. 1.—St. Agnes Earthquake, Cornwall, January 20th, 1905.

The shock was of the simple character common to all slight earthquakes. It consisted of a single prominent vibration, resembling a thud or blow, accompanied by a brief series of rapid tremors. The estimates of the duration range from 2 to 5 seconds, the average of five estimates being 3½ seconds.

The sound was heard by all the observers. It was compared to passing waggons, etc., in 27 per cent. of the records, to thunder in 42 per cent., to wind in 3, to loads of stones falling in 3, to the fall of a heavy body in 9, to explosions in 12, and to miscellaneous sounds in 3 per cent. The beginning of the sound preceded that of the shock in 69 per cent. of the records, and coincided with it in 31 per cent.; the end of the sound preceded that of the shock in 54 per cent. of the records, coincided with it in 38, and followed it in 8 per cent.

It follows, from the incomplete seismic evidence, that the mean direction of the originating fault is about north-east and south-west, its

distance from land being about 5 or 6 miles. The fault-slip was probably several miles in length, and that its depth was inconsiderable is shown by the closeness of the isoseismal 5 and 4. The rapid decline in the intensity of the shock, of which this closeness is indicative, also characterised the submarine Penzance earthquake of 1904.

4. *Fort William Earthquake: May 7th*, 1906.—Time of occurrence, 8.20 p.m.

A slight shock felt at Fort William, lasting about 2 seconds, and preceded by a rumbling noise. The earthquake was probably due to a small slip of the northern boundary fault of the Highlands.

5. *Carnarvon Earthquake: June 29th*, 1906.—Time of occurrence, 3.2 a.m.; intensity, 4; centre of disturbed area in lat. 52° 9·2′ N., long. 4° 10·7′ W.; number of records 23, from 15 places, and 17 negative records from 13 places. (Fig. 2.)

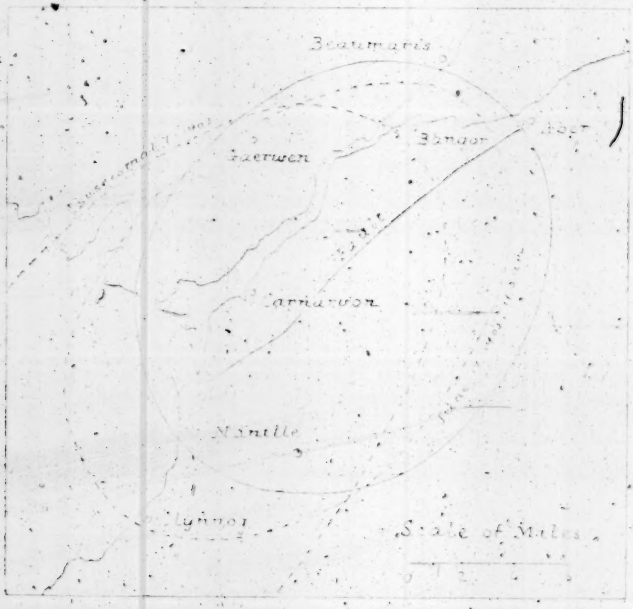


Fig. 2.—Carnarvon Earthquake, June 29th, 1906.

The continuous line on the map (Fig. 2) represents the boundary of the disturbed area, which is 16 miles long from north-east to south-west, 14½ miles wide, and contains about 182 square miles. Its centre is about 4 miles E. 15° N. of Carnarvon, and 11 miles E. 40° N. of the centre of the isoseismal 7 of the principal earthquake of June 19th, 1903. The curve is too nearly circular in form, and is not drawn with sufficient accuracy to enable the direction of its longer axis to be given more approximately than north-east and south-west.

The shock consisted of a single series of vibrations, lasting as a rule only a few seconds.

The sound, which lasted about 5 seconds, was heard by all the

observers, and was compared to passing waggons, &c., in 32 per cent. of the records, to thunder in 53 per cent., to wind in 5, to loads of stones falling in 5, and to miscellaneous sounds in 5 per cent.

The chief interest of this earthquake consists in its relation to the Carnarvon earthquakes of June 19th, 1903. The isoseismal 7 of the principal earthquake (which occurred at 10.4 a.m.) is an elongated ellipse, 33½ miles long and 15 miles wide, with its centre 4 miles west of Penygroes, and its longer axis directed N. 40° E. The earthquake was probably caused by a slip along a submarine continuation of the Aber-Dinlle fault, part of the course of which is shown in Fig. 2. Shortly afterwards, on June 19th at 10.9 a.m. and 11.8 a.m., and June 21st at 8.6 a.m., three after-shocks occurred with their foci near the north-east margin of the principal focus. The boundary of the disturbed area of the second of these shocks is represented by the broken line in Fig. 2. It is 20 miles long, 13 miles wide, and contains 219 square miles, its centre being 8 miles north-east of that of the principal earthquake and 2½ miles south-west of that of the earthquake of 1906, and the direction of its longer axis N. 47° E. This line may also be taken to represent approximately the boundaries of the other two after-shocks referred to above.

It is clear that the earthquake of 1906 must be regarded as an after-shock of the earthquake of 1903, its focus being situated within or slightly beyond the region disturbed in 1903.

6. *Derby Earthquake: August 27th, 1906.*—Time of occurrence, 5.56 a.m.; intensity, 5; centre of isoseismal 5, in lat. 53° 0·8′ N., long. 1° 42·3′ W.; number of records 131, from 79 places, and 85 negative records from 79 places. Fig. 3.

Time of Occurrence.—The number of records of the time of occurrence is 72, and the mean of 13 records, which are considered by their observers as accurate to the nearest minute, is 5.56 a.m.

Isoseismal Lines and Disturbed Area.—The continuous curves on the map (Fig. 3) represent isoseismals of intensities 5 and 4, and the broken line the isoseismal 7 of the Derby earthquake of July, 3rd, 1904. The isoseismal 5 is elliptical in form, 17 miles long, 11 miles wide, and 147 square miles in area. The longer axis is directed about N. 25° E. The centre of the curve lies 1 mile south-east of Ashbourne and is less than a mile from the centre of the isoseismal 7 of the earthquake of 1904. The isoseismal 4, which is not so accurately drawn, is 48 miles long, 36 miles wide, and contains about 1,360 square miles. The distance from the isoseismal 5 both to the north-west and south-east is 13 miles. The shock was also felt at eight places outside the isoseismal 4—at Sheffield, 3 miles to the north; Wollaton, Nottingham, Sherwood, Ruddington, and Calverton, which lie east of the isoseismal at distances of 1½, 4, 4, 5, and 5½ miles respectively; and at Thrumpton and Kingston-upon-Soar, which are respectively 2½ and 3 miles to the south-east. The whole disturbed area must therefore contain about 2,100 square miles.

Nature of the Shock.—To the great majority of the observers the shock appeared to consist of a single series of vibrations, with a mean duration of 2·7 seconds. According to 11 observers, however, the shock consisted of two distinct parts, separated by an average interval

of 2½ seconds, one part being so much weaker than the other that it generally escaped notice. The first part was the stronger at Breaston, Clifton, Edlaston, and Morley, and the second at Bradbourne and Kirk Ireton. Of these places, Morley lies on the minor axis of the isoseismals, Breaston, Clifton, and Edlaston on the south side of it, and Bradbourne and Kirk Ireton on the north side. As the two parts differed considerably in strength, the observations on the relative intensity of the two parts are more accurate than usual, and it may therefore be concluded that a second focus lay a few miles north of the Ashbourne focus, the concavity of the synkinetic band facing the second focus. Thus the impulse in the Ashbourne focus was much the stronger and occurred slightly before the other, but the interval between the two impulses was less than the time required to traverse the interfocal region. The earthquake was thus a true twin earthquake.

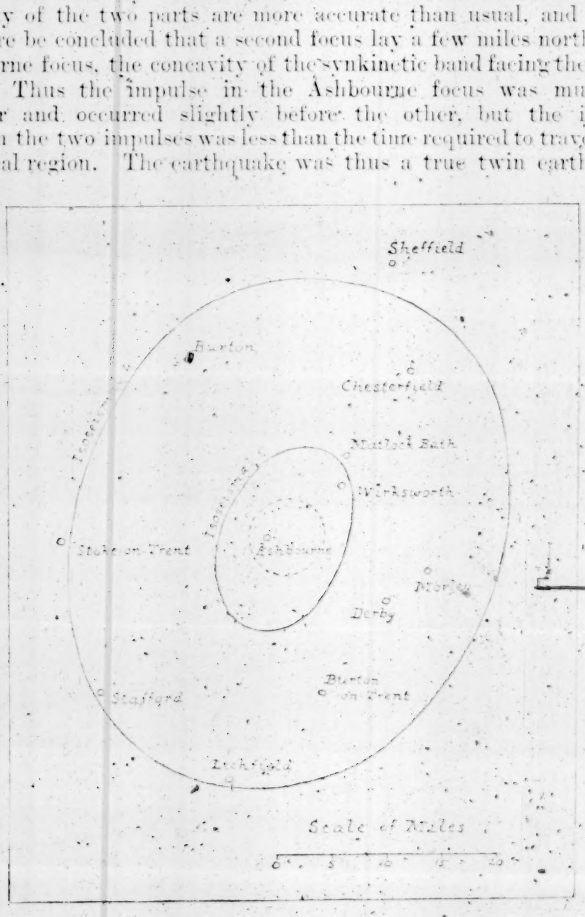


FIG. 6.—The Derby Earthquake, August 27th, 1906.

The evidence is insufficient to determine the position of the second focus. The mean interval between the two parts was, however, almost exactly the same as in the earthquake of 1904 (2·6 seconds as compared with 2·1 seconds), and it is therefore probable that the second focus

coincided with the northern focus of 1903 and 1904, lying about three miles west of Wirksworth.

Sound-phenomena.—Towards the east the sound-area extends as far as the isoseismal 4, but in other directions the observations are not sufficient to determine the course of its boundary. The sound was heard by 88 per cent. of the observers within the isoseismal 5, and by 64 per cent. in the zone between the isoseismals 5 and 4; altogether by 71 per cent. of the observers. It was compared to passing waggons, etc., in 61 per cent. of the records, to thunder in 13 per cent., to wind in 4, to loads of stones falling in 10, to the fall of a heavy body in 9, and to explosions in 4 per cent. The beginning of the sound preceded that of the shock in 54 per cent. of the records, coincided with it in 35, and followed it in 11 per cent.; while the end of the sound preceded that of the shock in 24 per cent. of the records, coincided with it in 48, and followed it in 28 per cent. The duration of the sound was greater than that of the shock in 59 per cent. of the records, equal to it in 37, and less than it in 4 per cent.

Origin of the Earthquake.—The three Derby earthquakes of March 24th, 1903, July 3rd, 1904, and August 27th, 1906, in all probability originated in the same twin foci, the epicentre of one being about a mile east of Ashbourne and that of the other about three miles west of Wirksworth, and the distance between them about seven or eight miles. The earlier earthquakes were followed by slighter shocks, the first after 40 days (on May 3rd, 1903), and the second after eight hours, both originating in the interfocal region of the fault.

The longer axes of the inner isoseismals of the principal earthquakes were directed N. 33° E. in 1903 and N. 31° E. in 1904; while those of the inner isoseismals of the after-shocks were directed N. 25° E. in 1903 and N. 27° E. in 1904. In each of the principal earthquakes the hade within the south-west or Ashbourne focus is to the north-west. Now, if the hade within the north-east or Wirksworth focus be towards the south-east, the greater expansion of the isoseismals for each focus on the side towards which the fault hades would cause a displacement of the north ends of the larger axes of the compound isoseismals towards the east. Thus, the divergence between the isoseismal axes of the principal earthquakes and the after-shocks shows that the fault-changes hade in the interfocal region, and that the true mean direction of the originating fault is about N. 26° E. This agrees almost exactly with that deduced from the earthquake of 1906, namely, N. 25° E., the isoseismals of this earthquake being unaffected by the impulse within the Wirksworth focus.

In each of the three earthquakes the impulse within the south-west focus was the stronger; but in 1903 the impulses occurred simultaneously, in 1904 the north-east focus, and in 1906 the south-west focus, was first in action. The existence of a synkinetic band in each case shows that all three were true twin earthquakes, the interval between the impulses being less than the time occupied by the earth-waves in traversing the interfocal region.

7. *Oban Earthquake: January 17th, 1907.*—Time of occurrence, 1.54 p.m.; intensity not less than 6; centre of disturbed area in about lat. 56° 26′ N., long. 5° 21′ W.; number of records 57, from 36 places.

The area disturbed by the earthquake is for the most part sparsely inhabited, and I have not been able to obtain sufficient records for drawing any isoseismal lines. So far as I can ascertain, the boundary of the disturbed area is an ellipse, passing to the north of Fort William and Inverlochy, some miles to the west of Aros-in-Mull, and to the south of Ardrishaig, Lochgilphead, Glendaruel, and Carrick Castle in Argyllshire. This curve, which I have not reproduced on account of its approximate nature, is about 69 miles long, 58 miles wide, and contains about 3,100 square miles. Its centre is about 5 miles east of Oban, and its longer axis is roughly parallel to the north-western boundary fault of the Highlands. The intensity of the shock was probably 6, but it was strong enough to cause some slight damage to buildings at Kilninver and Cuilfail Hotel (Kilmelford).

The shock consisted of two distinct parts, of which the first was regarded as the stronger at Aros and Kilmore (near Oban), and the second at Delavich and Inverinan (near Kilchrenan) and Port Appin. The mean duration of the shock was 5½ seconds, and that of the interval between the two parts 2·3 seconds.

The sound was heard by 98 per cent. of the observers, and was compared to passing waggons, etc., in 44 per cent. of the records, to thunder in 23 per cent., to wind in 2, to loads of stones falling in 10, to the fall of a heavy body in 4, and to explosions in 17 per cent. The beginning of the sound preceded that of the shock in 67 per cent. of the records, coincided with it in 29, and followed it in 4 per cent.; while the end of the sound preceded that of the shock in 8 per cent. of the records, coincided with it in 38, and followed it in 54 per cent. The duration of the sound was greater than that of the shock in 81 per cent. of the records and equal to it in 19 per cent.

The earthquake may have been caused by a slip along the great northern boundary fault of the Highland district, but the evidence is so scanty that nothing more than the possibility of such a connection can be suggested.

8. *Ochil Earthquake: June 14th*, 1907.—Time of occurrence, 1.59 a.m.

A slight shock felt at Menstrie, consisting of two vibrations, and accompanied by two banging noises.

9. *Ochil Earthquake: Jan. 20th*, 1907.—Time of occurrence, 3.36 p.m.; intensity, 4; number of records 2, from 2 places.

A rather strong shock, felt at Alva and Menstrie, and preceded and accompanied by a loud rumbling noise.

10. *Swansea Earthquake: July 3rd*, 1907.—Time of occurrence, 3.40 a.m.; intensity, 4; centre of isoseismal 4, in lat. 51° 38·1′ N., long. 4° 2·8′ W.; number of records 21, from 14 places, and 13 negative records from 12 places.

The boundary of the disturbed area is an isoseismal of intensity 4, and is 23 miles long, 14 miles wide, and about 250 square miles in area. Except towards the east, it coincides with the isoseismal 8 of the earthquake of June 27th, 1906. Its centre is 5 miles west of Swansea, and 2 miles west of that of the isoseismal 8 of the earthquake of 1906. The direction of the longer axis is approximately E. 4° N.

The shock consisted of a single series of vibrations, with an average duration of 3¼ seconds. The sound was heard by all the observers.

and was compared to passing waggons, etc., in 27 per cent. of the records, to thunder in 45 per cent., to the fall of a heavy body in 9, and to miscellaneous sounds in 18 per cent. The beginning of the sound preceded that of the shock in 86 per cent. of the records, and coincided with it in 14 per cent.; while the end of the sound preceded that of the shock in 14 per cent. of the records, coincided with it in 28, and followed it in 57 per cent.

Since the direction of the longer axis is parallel to that of the isoseismal 8 of the earthquake of 1906, and the line joining the epicentres of the two earthquakes is very nearly parallel to the longer axis, it follows that the Swansea earthquake of 1907 was caused by a slip of the fault that was in action the year before, the region of maximum displacement being about two miles farther to the west.

11. *Ochil Earthquake: July 5th*, 1907.—Time of occurrence, 9·48 p.m. A slight shock, consisting of a single vibration, felt at Menstrie.

12. *Ochil Earthquake: July 21st or 28th*, 1907.—A slight shock felt early in the evening (between 5 and 7.30) at Menstrie. The day was one of the last two Sundays in July, but which of the two, unfortunately, cannot be ascertained, as the information was communicated some time after the occurrence of the shock.

13. *Ochil Earthquake: September 18th*, 1907.—A very slight shock felt at Menstrie at about 5.30 p.m.

14. *Malvern Earthquake: September 27th*, 1907.—Time of occurrence, 8.12 a.m.: intensity, 5: centre of isoseismal 5, in lat. 52° 6·6′ N., long. 2° 16·8′ W.: number of records 107, from 40 places, and negative records from 6 places.

Of 89 estimates of the time of occurrence, 14 are regarded by their observers as being accurate to the nearest minute, their average being 8.12 a.m.

The isoseismal 5 is 9 miles long, 7 miles wide, and contains 48 square miles. Its centre lies 1½ miles east of Great Malvern station, and its longer axis is directed N. 6° E. The outer isoseismal, of intensity slightly less than 4, is 18 miles long, 14½ miles wide, and 206 square miles in area. The distance between the two isoseismals is 3½ miles on the west side and 4 miles on the east. Outside the latter curve the earthquake was perceived at six places by persons under favourable conditions, the shock and sound at Longworth (8½ miles west of the isoseismal) and Preston (2½ miles south-west), the sound only at Redmarley D'Abitot (½ mile south), and the shock only at Elmbridge (6½ miles north-east), Cheltenham (8 miles south-east), and Charlton Kings (9½ miles south-east). Thus the total disturbed area must contain about 800 square miles.

At most places the shock consisted of a single violent jerk, like that caused by the fall of a heavy body or an explosion of dynamite. Close to the centre the thud was followed by a slight vibration. At three places (Mathon, Welland, and Worcester) two vibrations were felt, the second being the stronger. Near the boundary of the disturbed area the shock was felt as a slight tremor or quiver. The mean duration of the shock was 2 seconds.

The sound-area coincides nearly with that contained by the outer isoseismal, but overlaps it towards the west. The sound was heard by

94 per cent. of all the observers, by 95 per cent. within the isoseismal 5, and by 93 per cent. in the zone between the two isoseismals. Within the isoseismal 5, the sound is compared to passing waggons, etc., in 29 per cent. of the records, to thunder in 9 per cent., to wind in 5, to loads of stones falling in 12, to the fall of a heavy body in 20, and to explosions in 19 per cent.; in the area between the isoseismals, the sound is compared to passing waggons, etc., in 44 per cent. of the records, to thunder in 11 per cent., to wind in 3, to loads of stones falling in 17, to the fall of a heavy body in 8, and to miscellaneous sounds in 3 per cent. Thus, references are made to types of short duration in 57 per cent. of the records within the isoseismal 5, and in 40 per cent. of the records in the surrounding zone.

The beginning of the sound preceded that of the shock in 46 per cent. of the records, coincided with it in 46, and followed it in 8 per cent.; while the end of the sound preceded that of the shock in 5 per cent. of the records, coincided with it in 58, and followed it in 37 per cent. The duration of the sound was greater than that of the shock in 56 per cent. of the records and equal to it in 44 per cent.

From the seismic evidence it may be inferred that the mean direction of the originating fault is N. 6° E., that its hade (as determined by the relative position of the isoseismals and the westerly overlapping of the sound-area) is towards the east, and that the fault-line passes a short distance to the west of the centre of the isoseismal 5, i.e. not far from Great Malvern. Now, the mean direction of the fault that runs along the east side of the Malvern Hills is N. 4° E. near Great Malvern, its hade is to the east, and it passes through Great Malvern.

There can thus be little doubt that the earthquake was caused by a small slip of this fault in the neighbourhood of Great Malvern. That the depth of the focus was small is shown by the sharp, abrupt character of the shock near the central area, fading away to a tremor near the outer margin.

This is the only movement along the Malvern fault with which I am acquainted, and certainly none of any consequence has taken place during the last 19 years.[1]

Earth-shakes in Mining Districts.—Earth-shakes resembling those so frequently felt in mining districts were observed at and near Abercarn (Monmouthshire) on February 11, 1904, Camborne on September 5th, 1904, Eastwood (Nottinghamshire) on September 17th, 1904, and Pendleton (near Manchester) on November 25th, 1905. The Pendleton earth-shake has been described in a recent paper in this Magazine.[2]

Abercarn: February 11th, 1904.—A smart shock, accompanied by a noise like a distant explosion, occurred at 2.30 a.m. In the colliery districts it was thought that a disaster had occurred in one of the mines. The shock was evidently local, for it was not felt at three

[1] I do not think that the occurrence of this slight earthquake lends any support to the suggestion (Quart. Journ. Geol. Soc., vol. lvi, 1900, p. 196) that great displacements have recently occurred along the line of fault.

[2] Geol. Mag., Dec. V, Vol. III (1906), pp. 171–176.

places (Henllys, Machen, and Risca), which lie about 3 or 4 miles from Abercarn.

Camborne: September 5th, 1904.—Time of occurrence, 1.55 a.m.; intensity, 4; number of records 7, from 6 places, and negative records from 3 places.

The earth-shake was felt chiefly in the district between Camborne and Redruth, but, owing partly to its occurrence shortly after midnight, it was not so widely observed as the stronger shake of June 4th, 1902. The boundary of the disturbed area is similar to that of the earth-shake in 1902,[1] but falls short of it by about half a mile towards the north, west, and south. It is thus about 3½ miles long, 2½ miles wide, and 7 square miles in area, its longer axis being roughly parallel to that of the earlier shake, and consequently to the principal faults of the district. The shock was brief, its duration being not more than 2 seconds, and was accompanied by a noise which was supposed by one observer to be due to a fall of ground in Dolcoath Mine.

Eastwood: September 17th, 1904.—At about 5.30 p.m. a shock was felt at Eastwood, a mining village about 8 miles north-west of Nottingham. The shock was strong enough to shake crockery and make windows rattle loudly. It does not appear to have been felt at other places in the surrounding district.

Llwynypia: May 17th, 1907.—Time of occurrence, 3.15 p.m.; intensity, 5; centre of disturbed area in lat. 51° 38·2′ N., long. 3° 26·6′ W.; number of records 22, from 13 places, and negative records from 7 places; number of observations made in mines, 6.

During the last twenty years earth-shakes have occurred in the Rhondda valleys on June 22nd, 1889, April 11th and May 2nd, 1894, October 16th, 1896, and May 17th, 1907, but many others in all probability have escaped record. The epicentres in 1894 were situated about three-quarters of a mile east of Porth, the other three in the neighbourhood of Pentre and Llwynypia.[2]

The earth-shake of May 17th, 1907, occurred at 3.15 p.m. Near the centre of the disturbed area its intensity was 5, very nearly 6. The boundary of the disturbed area is an isoseismal of intensity 4, and is very nearly circular in form, about 4 miles in diameter and 13 square miles in area. Its centre is situated half a mile east of Llwynypia.

The shock in all parts of the disturbed area consisted of a single series of vibrations, lasting on an average for 1½ seconds. Close to the centre of the area, as at Llwynypia, it began with one or two strong vibrations, followed by others rapidly decreasing in intensity; while near the boundary, at Gelli and Cymmer, only a tremulous motion was felt. The sound was much louder near the centre of the area than near the boundary; at Llwynypia it was described as a violent report and a great crash, or compared to a locomotive charging a building; near the boundary it was either not heard at all or described as a dull thud or like a distant explosion. It was heard by 86 per cent. of the observers. In 62 per cent. of the records it is compared to the fall or banging of a heavy body or to an explosion or blasting; in the

[1] Geol. Mag., Dec. V, Vol. II (1905), pp. 221–2.

[2] Ibid., Dec. III, Vol. VIII (1891), p. 371; Dec. V, Vol. VII (1909), pp. 124–5.

remaining cases generally to thunder. The beginning of the sound coincided in every case with that of the shock, while the end of the sound and shock were also as a rule simultaneous.

The earth-shake was observed in pits at Llwynypia, Wattstown, Gelli, and Ynyshir; in the two first at a depth of 500 yards. Gelli is close to the boundary of the disturbed area, and Ynyshir about half a mile distant, so that the disturbed areas on the surface and in pits were roughly coincident. At Llwynypia the sound was described as a terrific crash, followed by low, deep rumbling.

The centre of the disturbed area lies close to the termination (as mapped) of the Cymmer fault, and on its downthrow side. The earth-shake was thus in all probability due to a slip of this fault, brought about by the withdrawal of coal, etc., from the mine below.

Doubtful Earthquakes.

Church Stretton: October 22nd, 1904.—Time of occurrence, about 10.50 p.m.; intensity, 4: number of records 13, from 5 places, and negative records from 5 places.

The five places at which the shock was felt (Church Stretton, Shelve, Stapleton, Stiperstones, and Woolstaston) lie within an oval curve, 10½ miles long from north-east to south-west, 8½ miles wide, and containing about 70 square miles. The centre of the area is about 10 miles south-west of Shrewsbury. The shock was brief and slight, and was accompanied by a loud noise, which was compared to the roar of a train passing close at hand, the fall of a heavy body, or an underground explosion.

Holyhead: June 26th, 1907.—At 9.5 a.m. a shock of intensity 4, consisting of a single series of vibrations, was felt at Holyhead. It was preceded by a sound like the passing of a heavy vehicle.

Reported Earthquakes.

A large number of disturbances, supposed to be those of earthquakes, have been reported during the years 1904–1907. In the present section are included only those of which accounts have been inserted in newspapers. If they are not all due to artificial disturbances, the evidence seems to me insufficient to entitle them to the rank of doubtful earthquakes.

Napton (Warwickshire): January 26th, 1904.—At 12.4 a.m. a slight shock was felt, followed by tremors that were distinctly perceptible for 15 to 20 seconds. Inquiries made in the local newspapers elicited no further accounts.

Aberystwith: July 13th, 1904.—At 8.10 a.m. a rumbling sound was heard, and at 10.28 a.m. a rather strong shock, accompanied by a loud rumbling sound, was felt. Inquiries made in the district around Aberystwith show that the disturbances were confined, or practically confined, to that town.

Newbury: November 25th, 1904.—Shortly before noon, and again after 3 p.m., dull reports, accompanied by the shaking of windows, were heard near the borders of Hampshire and Berkshire, to the east of Salisbury Plain. The area from which I have received records is 24 miles long from east to west, 22 miles wide, and contains about

415 square miles. Gun practice was, I am informed, being carried out on the Plain, and there can be no doubt, I think, that this was the origin of the disturbances, for the following reasons:—

(i) The wind at the time was from west and north-west.

(ii) The disturbances occurred at nearly regular intervals, on each occasion lasting from 15 to 20 minutes.

(iii) The impulses obviously travelled through the air, shaking windows, etc., but in no place giving rise to a characteristic earthquake-shock.

(iv) The sound was compared either to thunder or gun-firing (in several instances to gun-firing on Salisbury Plain)—in the west part of the area always to gun-firing, in the centre more frequently to gun-firing than to thunder, and at the east end more frequently to thunder than to gun-firing. The area over which the disturbances were observed stops short of Salisbury Plain by several miles; for, as usual, in the immediate district the reports would be at once assigned to their true origin.

Barnet: March 15th, 1905.—A sharp shock was felt at 1.59 p.m., shaking doors and windows, and a loud sound was heard. The disturbance was also heard at Hadley (near Barnet).

Llangollen: May 1st, 1905.—At 1.40 a.m. a shock was felt at the Shropshire Militia encampment near Llangollen. The vibrations lasted 4 seconds and travelled from east to west, and were accompanied by a dull rumbling sound resembling thunder. Though I can assign no definite cause for the disturbance, it is quite improbable that a shock of such intensity should not have been felt in the surrounding country.

Ashbourne: April 23rd, 1907.—A slight shock is said to have been felt during the early hours of the morning in the Ashbourne district and at Uttoxeter. Numerous inquiries have resulted in negative evidence only, with the exception of one account from Church Broughton, where a shock of intensity 5 was felt at 12.40 a.m. If this disturbance were of seismic origin it could not fail to have been more widely felt.

Dochgarroch (near Inverness): July 29th, 1907.—The *Inverness Courier* reports three shocks at 3.20 a.m., 4.35 a.m., and 6.15 a.m., of which the second was the strongest. Dochgarroch lies close to the epicentres of most of the earthquakes of September, 1901, and it is possible that slight local shocks may still be felt there. The evidence on this occasion, however, probably rests on the experience of a single observer.

IV.—Carboniferous Fish-Remains in North Derbyshire.

By J. Wilfrid Jackson (of the Manchester Museum).

SOME time ago Mr. R. Cairns, of Ashton-under-Lyne, sent me for identification a large collection of fossil fish-teeth, which he had obtained in a limestone quarry near Sparrowpit, in North Derbyshire, not far from the celebrated "ebbing and flowing well."

Later on, at his request, I went through his large collection and made a further selection, and also paid a visit to the quarry myself

and obtained other examples. The quarry is evidently that from which Mr. T. Parker, of Oldham, obtained the large series described by Mr. J. W. Davis in the Geological Magazine, 1886, p. 148.

The majority of the teeth are free from matrix, having been carefully broken out. They are, however, very much rolled and abraded, which rendered their ready identification a very difficult matter, and I have to thank Dr. A. Smith Woodward for his kindness in helping me to name most of them.

By far the greater number belong to *Psephodus magnus* (M'Coy), and consist largely of thick dental plates of moderate size with the outer border slightly inrolled, some specimens exhibiting strong vertical plications on the sides of the crown. The lateral margins of some individuals are cleft at one or both sides. Along with the larger teeth are a number of small narrow oblong specimens with one end usually wider than the other, the middle being slightly wider than the widest end. The surface is polished and quite smooth, and there is no osseous base attached. Some of the specimens have the sides of the crown strongly plicated vertically. These smaller teeth appear to agree with the so-called *Helodus planus*, L. Agassiz.

Psammodus rugosus, Agassiz, is represented by several more or less worn and broken crowns, the largest being 1⅝ inches in breadth and the portion of the length remaining measures 1⅝ inches. Amongst the numerous specimens from this quarry are a few examples of a species not hitherto recorded from this part of Derbyshire, viz. *Petalodus acuminatus*, Agassiz. It is given as "rare in the Carboniferous Limestone of Derbyshire" in M'Coy's "British Palæozoic Fossils," but no locality is stated. In the "British Museum Catalogue of Fossil Fishes," pt. i. p. 43, several references are made to its occurrence at Ticknall, South Derbyshire.

The examples from the Sparrowpit locality are very fragmentary and of small size, and are difficult to extract from the matrix. Along with the various teeth, and free from matrix, were one or two fragments of bone-like tissue which Dr. Woodward kindly identified as selachian cartilage. Some facts about the quarry and matrix are worth noting. As mentioned by Davis, the matrix is a "light-coloured crystalline limestone," but further than this it is found on close examination to be a conglomerate of small round and oval pebbles and comminuted shells, a point unobserved by Davis. Messrs. Barnes & Holroyd, in their very excellent papers[1] "On the Occurrence of a Sea-beach at Castleton, Derbyshire," note this fact and say that in the beds at Bolt Edge quarry, Sparrowpit, the pebbles are very much smaller than those at Castleton. They also put forward the question as to whether the numerous cestracion fishes, the teeth-remains of which are very common at Bolt Edge, played any part in reducing the shells to smaller fragments. This, of course, is highly probable, but in my opinion the fish-teeth have also been thrown up on the old sea-beach, judging from their numbers and their rolled and abraded condition.

[1] Trans. Manch. Geol. Soc., vol. xxv, p. 119. See also vol. xxv, p. 181; vol. xxvi. p. 466; vol. xxvii. p. 82.

V.—The Tygerberg Recumbent Fold.

By Dr. C. Sandberg, Arnhem, Holland.

AFTER a prolonged and very careful study of the region on the spot as well as from existing literature, I summarised my observations and conclusions, in 1906, in a paper on the interesting and peculiar formation of the Tygerberg range in the Cape Colony.[1]

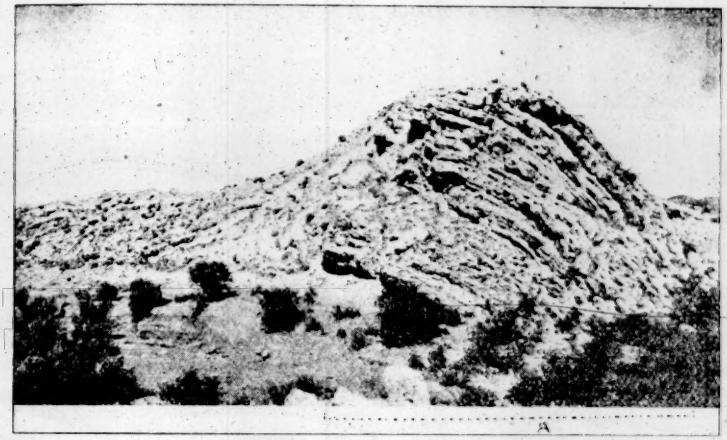


Fig. 1.—Reproduction of photograph of the western side of the Tygerberg-poort (=gap), Tygerberg range, Cape Colony. (The dotted line A corresponds with the dotted line A in the diagram, Fig. 2.)

The first question to be decided here is: Can we explain the peculiar mutual stratigraphical relations between the Witteberg quartzites and the Lower Dwyka and Ecca Series and their tectonic behaviour by assuming that this range represents a squeezed-up anticlinal fold? A second question might naturally follow, viz.: How are we to explain the occurrence of this range should field evidence be in contradiction with the above assumption? It would seem that Professor E. H. L. Schwarz presumes to settle this intricate geological problem by the simple exhibition of a single photograph and the reference to another one,[2] in favour of his 'squeezed-lead' theory. To these I may be allowed to oppose my photograph (Fig. 1) of the western side of the Tygerberg-poort (=gap) and my ideal section (Fig. 2), the north corner of which is simply a copy of the behaviour of the strata as reproduced on the above-mentioned photograph.

Another photograph taken by me some two hundred yards to the north of the Tygerberg range represents a small 'lambeau' of Witteberg quartzites *in situ* (Fig. 3). This 'lambeau,' whilst reposing on Lower Dwyka, is separated from the Witteberg quartzite range

[1] See Trans. Geol. Soc. South Africa, vol. ix, 1906, pp. 82-89, pl. xxi.
[2] Geol. Mag., Dec. V, Vol. IV, 1907, No. XI, p. 487, Pl. XXII.
[3] Loc. cit., p. 489, and Geol. of Cape Colony, by A. W. Rogers, 1905, p. 141.

(Tygerberg) by Lower Dwyka, which again is supported by younger Dwyka and Lower Ecca, dipping first slightly to the south, then becoming vertical, and finally, further north still, assuming a northerly dip.

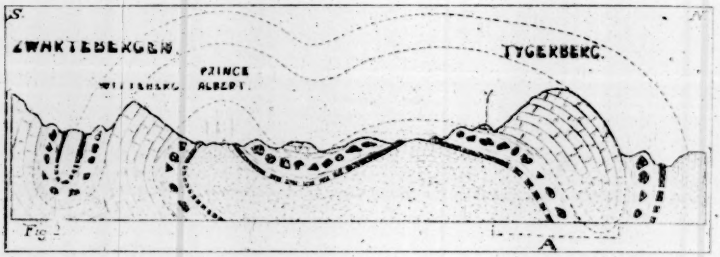


FIG. 2.—Diagram of Tygerberg range to show the behaviour of the strata seen in the photograph, Fig. 1, at the point A.

The strata are thus lying here in reversed stratigraphical order. A similar occurrence was observed by Professor Schwarz at the western end of the Tygerberg range, and to it he draws special attention, adding that a little further on he found the normal succession again.[1]

FIG. 3.—A small 'lambeau' of Witteberg quartzites *in situ*, 200 yards north of the Tygerberg range, reposing on Lower Dwyka Beds.

[1] "Geol. Survey of Parts of Prince Albert, etc.": Report Geol. Surv. Cape of Good Hope, 1904, p. 91.

North-east of the Tygerberg farm-homestead the Dwyka and Lower Ecca Series stand nearly vertical; east and west along their strike (parallel to and north of the Tygerberg) they become more and more inclined, and finally about 6 miles to the east and 4 miles to the west they are lying nearly flat. Some five hundred yards south-west of this farmhouse (and due south of where the Upper Dwyka and Ecca Series are still inclined close on to the vertical) the shales (Upper Dwyka or Lower Ecca) can be seen, right down at the bottom of the river, to dip towards the main range (south) and under the Dwyka conglomerate. These shales are lying very near the horizontal.

To the south of the range the Dwyka and Ecca Series are lying practically horizontal, carrying numerous fragments of Witteberg quartzites *in sitû*. North and south of the central part of the Tygerberg range the Dwyka and Ecca Series are consistently lying asymmetrical, namely, nearly horizontal to the south and nearly vertical to the north of the Witteberg quartzites, after the way illustrated in my sections.[1] I fail to see how this behaviour of the strata is reconcilable with the squeezed-lead-vice theory.

Going over to the larger mass of Witteberg Beds, south of the Tygerberg, facing the Zwartebergen, we again find fragments (lambeaux) of Witteberg quartzites lying in such positions to the north of the main range as to clearly point to an overfold. When, therefore, Professor Schwarz declares[2] that "the difficulty which the Tygerberg presents is that although the quartzites tower up in a narrow vertical anticline, the Dwyka shales and conglomerate around it are only moderately inclined, and indeed in some places lie actually flat," the question, for the mere pleasure of being able to put it into a nutshell, is so disfigured and cut down as to render it entirely unrecognisable.

Finally, I fail to understand either the strength or the meaning of the argument that "there is no break in the succession [of the beds in the larger mass of Witteberg Beds fronting the Zwartebergen] whence the root of the supposed overfold could have originated." Professor Schwarz surely does not mean to convey the impression that the Witteberg Beds here form a closed anticlinal. He knows the region too well to make a statement which is in actual contradiction to the evidence in the field.

Summarising, we must conclude that in and near the Tygerberg range the mutual relations (*lagerungs Verhältnisse*) between the Dwyka-Ecca Series and Witteberg quartzites are in contradiction to the squeezed-lead or mushroom-fold theory; they are, on the other hand, in harmony with the occurrence of a recumbent fold; therefore, even at the risk of endangering the present conception of the structure of the coast-ranges, I must adhere to the latter explanation of the Tygerberg phenomena until more serious contradictory evidence is forthcoming.

[1] Trans. Geol. Soc. South Africa, loc. cit.

[2] Geol. Mag., loc. cit.

REVIEWS.

I.—The Port of London and the Thames Barrage, a series of expert studies and reports, by T. W. Barber, M.Inst.C.E., and others. Issued by the Thames Barrage Committee. 8vo; pp. 193, with maps and other illustrations. London: Swan Sonnenschein & Co., 1907. Price 12*s.* 6*d.* net.

ONE of the difficulties which hampers the Port of London is the insufficient depth of water in the river for the increasing size and tonnage of ships, and the deepening of the river by dredging has been recommended as a remedy. Another and effective plan, if it could be carried out, is the one discussed in the very interesting work before us. As stated in the Introduction, "The Committee formed in 1903 to promote a public enquiry into the proposed Barrage across the Thames in the neighbourhood of Gravesend—thus converting the whole of the lower river into a freshwater lake—having so far failed to attain its main object, has instituted a series of expert enquiries and studies into the various questions which have arisen and are involved in the Barrage proposal."

The chief purpose of the volume is to deal with the objections that have been raised to the above scheme; and the most important are the questions of drainage and percolation.

The proposed barrage or dam would be made between Gravesend and Tilbury, and consist "of a straight monolith wall of Portland cement concrete, faced with granite, founded on the Chalk and carried up to six feet above the highest known tide." Further, the upper surface of roadway and foot-pavements would be 100 feet wide, flanked with granite parapets, and the base or foundation width would be 175 feet, with tunnels for road and rail traffic.

The proposed level at which the Thames would be maintained is Trinity High Water or 12 ft. 6 in. above Ordnance Datum. The area upheld would be between Gravesend and Teddington, a distance of 46½ miles.

The main factor of geological import, and the most serious one for the inhabitants along the valley bordering this long portion of the river, is the infiltration and uprise of water that would take place in the adjacent porous strata.

This subject is dealt with in an able and candid manner by Mr. Clayton Beadle, who points out that large volumes of water would pass in from the river at different points, into the Chalk and Gravels, and, in addition, much flood-water from direct rainfall on the marsh lands would have to be dealt with. In another report Mr. T. Hennell estimates that more than one and a quarter million pounds would be required for pumping works and walls, and £33,000 per annum for the maintenance and working of pumps.

II.—The Falls of Niagara, their Evolution and varying Relations to the Great Lakes; characteristics of the power, and the effects of its diversion. By Joseph William Winthrop Spencer, M.A., Ph.D., F.G.S. 8vo; pp. xxxi, 490, with large map in pocket), 43 other maps and pictorial plates, and 30 text-figures. Ottawa, 1907.

THIS monograph on the geology and physics of Niagara Falls was prepared under a commission from Dr. Robert Bell, Acting Director of the Geological Survey of Canada, and it has been issued under the Department of Mines connected with that establishment.

The leading conclusions of the author were brought last year before the British Association, and were printed in the Geological Magazine for 1907 (pp. 440–1). We have now the satisfaction of calling attention to the completed work, in which the details of Dr. Spencer's long-continued and painstaking researches are published.

Lyell, during his visit to Niagara in 1841–2, came to the conclusion that the average rate of erosion of the chasm below the falls had been about one foot annually, and that "it would have required 35,000 years for the retreat of the Falls, from the escarpment of Queenstown to their present site." At the same time, as he pointed out, "we cannot assume that the retrograde movement has been uniform."[1]

These views are to a certain extent confirmed by Dr. Spencer, who estimates a total of 39,000 years as the age of the Falls, but he differs materially from Lyell in the evidence he brings forward to show that the recession of the first three miles occupied 35,500 years, and of the last four miles only 3,500 years.

Dr. Spencer now claims that "The recession of the Falls, from their birth to the present day, and for the future, has been determined, as well as their age." His investigations include soundings at all the changing points of the gorge, borings to ascertain the character of buried channel-beds, surveys of the old river banks, and observations on lake fluctuations. Thereby has he been enabled to estimate the changes that have occurred at different periods in the volume and currents of the river, and in the height of the Falls; gathering evidence from a study of the buried valleys, and of other phenomena that have influenced erosion far from the great cataract. Thus he concludes that originally the overflow from Lake Erie alone was discharged over the Falls, and progress in excavation was comparatively slow. Through subsequent earth-movements the drainage of Lakes Huron, Michigan, and Superior was added, and erosion was intensified.

The upper part of the Niagara Gorge has been excavated along the line of a pre-Glacial feature, within which the drainage was formerly in the opposite direction to that of the present day. The account given by the author of this "Falls-Chippawa channel" is, he believes, the first suggestion of its existence. Out of this trough the falls are now beginning to emerge, with consequent retardation of their recession.

[1] "Principles of Geology," 11th ed. 1872, vol. i. pp. 356, etc.

III.—Memoirs of the Geological Survey (England and Wales). The Geology of the Country round Oxford. By T. I. Pocock, M.A.; with contributions by H. B. Woodward, F.R.S., and G. W. Lamplugh, F.R.S. London: Wyman & Sons, 1908. Price 2*s.* 3*d.*; price of quarter-sheet 1*s.* 6*d.*

THE Ordnance Survey of England has published a quarter-sheet having Oxford for a centre, with topography revised up to 1902. The Board of Agriculture desire to give notice of a colour-printed, special geological map of Oxford and district, of which the memoir is an explanation. This special sheet includes Abingdon, Eynsham, Islip, Brill, and Great Milton. The superficial deposits have been for the first time represented. "They include the broad alluvial tracts of Ot Moor and of the Thames and its tributaries; also the valley-gravels, and certain tracts of plateau-gravel regarded as Glacial Drift. Details are given of these deposits, and in connection with them the development of the rivers and origin of the scenery are discussed. The various Jurassic and Cretaceous rocks are also described, and there are notes on the economic products and water-supply, with records of deep borings."

The original Geological Survey was conducted by Messrs. Hull, Whitaker, Polwhele, and others during the years 1857 to 1863, and published on two separate sheets, of which the northern belonged to Banbury and the southern to Abingdon. The country was resurveyed by the late J. H. Blake and the authors of the present memoir, which has been published under the direction of J. J. H. Teall, D.Sc., F.R.S. The preparation of the memoir was entrusted to Mr. Pocock, who has dealt very fully with the Pleistocene and Recent deposits. The chapters dealing with the Jurassic rocks have been partly written by Mr. Woodward, those on the Lower Cretaceous rocks have been contributed by Mr. Lamplugh, and that on the Upper Cretaceous rocks is based on the published observations of Mr. Jukes-Browne.

The general history of the Middle and Upper Oolitic rocks of England by Mr. Woodward formed, it will be remembered, the fifth volume of "The Jurassic Rocks of Britain," published in 1895 and reviewed in the Geological Magazine for 1896. In that volume the Jurassic rocks of the neighbourhood of Oxford naturally came in for their share of attention, and full justice was then done to this important subject. But the opportunity afforded by the publication of an entirely new map, with Oxford as centre, has been utilized by the Geological Survey for the production of a special memoir.

There are many reasons to justify this course; for, apart from the celebrity of the ancient city as a seat of learning and as the nursery of some of the earliest English geologists, its situation in the heart of a great number of Mesozoic formations has served to render Oxford classic ground in the annals of geology. There is a charming variety within the area delineated, and the introduction of superficial features, such as Alluvium, Valley-gravel, and Plateau-gravel, in a region so admirably sculptured by atmospheric agencies, has enabled the chartographer to produce one of the brightest geological maps that has hitherto been published. Most of the Mesozoic formations are represented within the area, though none occupy any great extent of surface

with the exception of the Oxford Clay, of whose original outcrop nearly one-half is masked by the alluvium and gravels of the Thames River system. Large collections of Jurassic fossils from the immediate neighbourhood enrich the Oxford Museum, but the Corallian rocks cannot vie in development and palæontological wealth with those of Dorset and North-East Yorkshire, neither do the scattered Portlandians in the south-east corner yield such a suite of fossils as may be found in Wilts and Bucks.

In dealing with the solid geology of the area a very comprehensive sequence of the Jurassic rocks is shown, whilst boring operations have yielded some interesting details respecting those beds which do not actually appear on the surface within the limits of the map. Thus, at Fawler the Inferior Oolite has already shrunk from the fine display on the Cotteswold escarpment to a thickness of 37 feet, whilst underneath Oxford the thickness of the Inferior Oolite is only 16 feet, and we may strongly suspect that it thins out to a feather-edge a little farther to the eastward. The easterly attenuation of the Lias is equally remarkable. Its thickness in the Northern Cotteswolds was proved to be 1,361 feet, and of this the Upper and Middle Lias account for 400 feet. Yet these two subdivisions are held to be absent under Oxford, where the actual thickness of the Lower Lias is at present unknown. These facts may be further confirmed from a study of the east and west section which accompanies the map, where both the chief borings about Oxford are represented as terminating in the Lower Lias, whose thickness at Burford was found to be 447 feet.

Bathonian beds, consisting of Great Oolite, Forest Marble, and Cornbrash, come to the surface in the extreme north-west corner of the map. It is probable that the Great Oolite, as a limestone series, attains its maximum development in Oxfordshire and the adjacent parts of Gloucestershire. With the Cornbrash the Lower Oolites are held to terminate, and on this rests the chief feature of the map, viz. the Oxford Clay with its Callovian base. The arenaceous features of this horizon must be feebly developed near Oxford; thus the rule that clays predominate hereabouts in the Middle Oolites may be said to prevail. Hence there is no special sandstone coloured in the map or column of explanation, merely a reference to "sand and clay" towards the base. On the scale attached to the map the thickness of the "Oxford Clay and Kellaways Beds" works out at about 450 feet, whilst on p. 25 the authors speak of the Oxford Clay as being "nearly 400 feet thick in this region." It is difficult to understand how such can be the case when the well at the city brewery only shows 240 feet of Oxford Clay down to the Cornbrash. There may be two reasons for this excessive estimate: first, the notion originally derived from Phillips' interpretation of the Wytham boring, which was corrected by Prestwich; second, the extraordinary thickness of the Oxford-Kellaways formation at Swindon, estimated at 572 feet. There is also another circumstance in connection with the Oxford Clay of this district which excites surprise, viz., that within the space of a 40 feet section in the Summertown pit *Cardioceras cordatum* occurs in the upper part, lower down there is *Cosmoceras Duncani*, and likewise *Kepplerites calloviensis*, together with *M. macrocephalus*. "Thus portions of the chief zones

of the Oxford Clay are here represented." If that can take place within 40 feet of beds, of what value are these particular ammonites for zoning 400 feet of beds?

The Corallian beds within the area receive their share of attention, and, being for the most part accessible and fairly fossiliferous in places, their history is not difficult of interpretation. Measured on the scale it would seem that the average development does not exceed 50 feet, including the Calcareous Grit at the base with the Coral Rag and Coralline Oolite at the top. In the explanatory column a wedge of Ampthill Clay is driven into the Corallian Series, which as a calcareous body disappears a little to the north-east of Oxford. The chartographer has also ventured to represent a considerable extent of Ampthill Clay in this quarter, separating the Oxford from the Kimeridge Clay. The adjacent Arngrove stone by its fauna seems to represent the Calcareous Grit. It is in this direction perhaps that the greatest change in the solid geology of the map occurs; since a very considerable area in the north-east corner formerly coloured as Lower Calcareous Grit, in the region between Boarstall and Waterstock, now appears as Ampthill Clay.

The Kimeridge Clay of the district probably nowhere exceeds 100 feet, a remarkable falling off from its development on the Dorset coast. One is tempted to speculate as to how far the Kimeridge Clay of Oxfordshire is the exact equivalent in time of the Kimeridge Clay of Dorset. Certainly there is no passage to be seen between the Kimeridge Clay and the Corallian, such as may be well observed in Ringstead Bay. The question then arises as to how far the basal beds of the Kimeridge Clay are developed in Oxfordshire. Good specimens of *Rhynchonella inconstans* are quoted from Sandford, and this fossil is characteristic of the lowest beds in Dorset; moreover, Sowerby figured *Ostrea deltoidea* from Headington, and this is also indicative of a low horizon, though not to be relied upon like the other fossil. Phillips is stated to have observed in the section on Shotover Hill, about 15 feet from the base of the Kimeridge Clay, a septarian band yielding *Rh. inconstans*, etc., whilst lower down there are layers of *Ostrea deltoidea*, and near the base *Thracia depressa* and *Exogyra virgula* are fairly abundant. Hence the relative position of these fossils is the reverse of that in Dorset. But there are exceptional features in the fauna of this region, for we note that *Perisphinctes plicatilis* is quoted from quite the top of the Kimeridge Clay in a boring at Baldon, and the same species of ammonite is quoted with a query from the Lower Portlandian of Shotover.

These considerations, however, do not materially affect the mapping, which must proceed mainly on lithological lines. Hence there is not much difficulty in determining the several Portlandian outliers which give such variety to the south-east corner of the map. In this connection, also, we observe that a considerable portion of the district, comprising the Baldons, formerly mapped as Lower Greensand, is now added to the Lower Portlandian. The thickness of the Portlandian at Shotover is estimated at rather over 100 feet. "This group," Mr. Woodward observes, "consists mainly of sandy strata with beds of limestone, as well as sand and thin clay-bands in the

upper part. The conventional division into Portland Sand and (overlying) Portland Stone appears applicable only to portions of this area, and even then it is better to use the terms Lower and Upper Portland Beds, as both divisions contain beds of sand, and in certain tracts the Lower beds pass into a loamy clay equivalent to the Hartwell Clay." In the explanatory column the Hartwell Clay is shown as part of the Lower Portland Beds, though on the map it is not possible to separate it from the Kimeridge Clay.

From the upper beds (sands and limestones) of Shotover the following are amongst the fossils quoted, viz., *Perisphinctes bononiensis*,[1] de Lor., *Cerithium portlandicum*, *Natica elegans*, *Pecten lamellosus*, and *Trigonia gibbosa*, all characteristic Upper Portlandian species. From the lower beds the following are amongst the fossils recorded, viz., *Perisphinctes pectinatus*, Phil., *Pholadomya tumida*, and *Trigonia Pellati*. This is rather a scanty list, but the Clavellate *Trigoniæ* are characteristic Lower Portlandian species almost as much as the *Glabræ* are characteristic of the Upper Portlandian, where some palæontologists would lump the several varieties under *Trigonia gibbosa*, Sow. In the outlier at Brill the boundary drawn at the base of the Portland Beds is in reality at the junction of the Upper Portlandian with the Hartwell Clay (Lower Portlandian), which merges downwards into the Kimeridge Clay. The base of the Upper Portlandian here is the highly fossiliferous glauconitic bed, in which J. F. Blake in 1893 found a series of what he regarded as Lower Portlandian fossils, including *Ammonites biplex*,[2] though some of the fossils quoted are likewise characteristic of the higher beds.

It may be said with a considerable degree of truth that, when correlation is attempted, the faunal history of the Kimeridge-Portland period does not tally with its lithology, although, if we confined our attention solely to the area included in the Oxford map,

[1] This form is sometimes taken for *Am. giganteus*, Sow., which fossil Blake showed to be restricted to the highest Portlandian beds of Portland Isle. Was Blake justified in altering *bononiensis* into *balgniensis*?

[2] It is interesting to observe that fifteen years ago so good a palæontologist as the late Professor Blake continued to call this characteristic Lower Portlandian fossil by the name of *biplex*. An equally distinguished palæontologist, de Loriol, gave a very good figure of it, but unfortunately also referred the Boulogne fossil to *A. biplex*, Sowerby. The Russians Nikitin and Pavlov, when they were over here twenty years ago, had pointed out that our Portlandian fossil was identical with *A. Fallasianus*, d'Orb. (in Murchison's "Russia"), which Pavlov then classed under *Perisphinctes*. Blake (Q.J.G.S. for 1902, p. 309) referred to a *Perisphinctes* like *Pallasi*, usually called *Am. biplex*. Subsequently Miss Healey (Q.J.G.S. for 1904) threw much light on Sowerbian nomenclature, and gave two excellent figures of *Oloostephanus Pallasianus*, d'Orb., in which we recognize a striking likeness to our old Kimeridge-Portland friend—a very *biplex* ammonite, but not Sowerby's species.

It must not be supposed, however, that the stratigraphist in search of a name for a zonal fossil is quite out of his difficulties. If palæontologists had been content not to subdivide the ammonites, there would have been no further cause for doubt. But are we quite certain that the "true *biplex*," i.e. *Am. Pallasianus*, belongs to the genus *Oloostephanus*? Many of the specimens of "*biplex*" in our rocks, owing to their evolute character and the presence of strictures, more resemble *Perisphinctes*. Moreover, we know that Neumayr, who is responsible for *Oloostephanus*, essentially a Cretaceous group, admitted that there were intermediate forms. It is significant also that he did not include *Am. Pallasianus*, d'Orb., amongst the *Oloostephani*.

this generalization might not be fully realized. Within this particular area there is not much difficulty in drawing the line between the attenuated representative of the Kimeridge Clay and the several Portlandian beds above it. But a question which may not trouble the chartographer arises, as to how far these lithological distinctions hold good over all that part of the South of England, from Dorset to the borders of Bedfordshire, where Kimeridge-Portland rocks are developed. If we are to judge by the invariant fossils, it seems probable that a given fauna was in one place being buried in clay, yet elsewhere in sand or even in calcareous deposits. Hence, what is regarded as Kimeridge Clay in the Isle of Purbeck may represent an horizon classed as Portlandian elsewhere. This is too large a question to be discussed within the limits of a review beyond intimating a belief that possibly the complete sequence at Swindon is the most likely place to afford a clue to the mystery. It is well known that J. F. Blake suggested the idea of a difference in the age of the several groups classed as Portland Stone (Upper Portlandian), those in the north-east being regarded as possibly older than those in the south-west, and particularly in Portland Isle.

The development of Purbecks within the area is so slight as to call for no comment, but the Ironsands of Shotover, including the Brill and Muswell Hill outliers, are of considerable interest, more especially from the circumstance that these were previously mapped by the Geological Survey as of Lower Greensand age. This was certainly contrary to the opinion of the older geologists, and also of Professor Phillips, who in the "Geology of Oxford," pl. xvi, figures species of *Paludina*, *Unio*, and *Cyrena* from these beds, some of them being new species, but, as usual, without description. There seems to be but little doubt that these Shotover Sands represent the marginal deposits of the great Wealden basin, and are themselves probably on the horizon of the Hastings Beds. By way of accounting for the previous interpretation of the Survey, it is stated that a ferruginated portion of the Portland Stone, containing *Trigonia Damoniana* and other marine fossils, had in some way led to the idea that there might be a passage from Portlandian to Ironsand conditions. This view seems to leave the intervening Purbecks out of consideration altogether. Sandy beds south of Newnham possess a scanty fauna of a Lower Greensand character, and these are succeeded in the south-east corner by the Gault.

The Superficial Deposits of the area are classed under the heading "Pleistocene" and "Recent," but since the writer (Mr. Pocock) regards it as probable that the country has been subjected to subaërial denudation "ever since the Eocene period," there seems to be a possible margin for deposits anterior to the Pleistocene, such for instance as some of the Plateau-gravel, in their memoir called Plateau Drift. Without entering into this subject, a glance at the history of the River-gravels may be of interest. There are four terraces in the Oxford district, of which the highest has not hitherto been found to contain fossil remains. The other three, which together constitute the low-level group, not rising more than 50 feet above the present rivers, contain the bones of *Elephas antiquus*, of the mammoth, woolly

rhinoceros, hippopotamus, and other mammalia, together with a good number of land and fresh-water shells of existing species, and flint implements regarded as early Palæolithic.

It is upon the second of these terraces that Oxford and most of the villages of the Upper Thames valley are built. These gravels are occasionally cemented by iron-oxide into a rock hard enough to be used for a building-stone. It is in this terrace that important finds of the large Pleistocene mammalia have been made. The changes in the courses of the rivers since the epoch of the second terrace have not been very great, the most important being in the case of the Cherwell. The third terrace has also yielded Palæolithic implements and mammalian remains. Eleven species of fluviatile shells have been obtained from the sand included in one of the gravel beds. There is also a peat bed, where about two-thirds of the mosses, as well as the flowering plants, are still found living in the neighbourhood; some of the others are Arctic or Alpine.

The gravels hitherto described may be classed as the low-level group, but between them and the Fourth Terrace there occurred a marked epoch of erosion, during which the Thames cut down its valley to the extent of about 50 feet. It has already been stated that no fossils have been found in this terrace, and the same rule applies to the Plateau-gravel, which Mr. Pocock describes as the Northern Drift. It will be readily understood that mere fragments of this once extensive formation remain, capping portions of the higher grounds, where its presence is indicated on the map by the usual pink colour. It is thought that this drift has an eastern as well as a northern source, but the subject is a too extensive one to be dealt with in a local notice. We must leave the Plateau-gravel and the development of river valleys for the present, merely remarking that, according to Prestwich, since the beginning of the Pleistocene period, when the so-called 'Westleton Beds' were formed, there has been erosion of the valleys to a depth of 450 feet, the greater part of which was accomplished in Glacial times. Maps showing denudation of valleys since the formation of the High Terrace, and since the epoch of the Wolvercot Terrace, are supplied in the text. There can be no doubt that speculative physiography is a very popular branch of geology, and one which has come to the front enormously of late years. Mr. Harmer's paper on "Lake Oxford and the Goring Gap" is a testimony to the interest which the subject has evoked.

The question of water supply is dealt with in the latter part of the memoir. The original supply of water to Oxford was obtained from wells sunk in the Valley-gravel. There are also numerous springs which are thrown out where the water in the various sands, principally of Jurassic age, is held up by the underlying clays. Hence the supply of surface water may be deemed fairly adequate, and it is fortunate that this is the case, since artesian boring in the valley of the Upper Thames cannot be regarded as a success. This is due to the salinity of water from strata below the Great Oolite, which is not as yet satisfactorily explained; but it will be remembered that even the Forest Marble in the Swindon deep well yielded a water almost as saline as that of the sea. We fully concur in the remarks of Mr. Fisher that

"the study of Oolite waters leads to the general conclusion that the uncovered beds of limestone yield calcareous waters of a hard character, while the deep beds, and especially the beds covered by clay, yield saline or alkaline supplies." To a certain extent this rule holds good even in such a homogeneous formation as the Chalk, and may be explained on the principle that the higher and more exposed beds receive a larger charge of carbonic acid: where this does not penetrate, the carbonate of lime is not dissolved. The source of such large quantities of a saline matter is probably the stagnant condition of the waters in the hydrostatic basin, which require bleeding by springs or else by continuous pumping, which latter process might be prolonged indefinitely.

W. H. H.

IV.—The Geology of Coal and Coal-mining. By Walcot Gibson, D.Sc., F.G.S. pp. x, 341, with 8 plates and 16 text-illustrations. London: Edward Arnold, 1908. Price 7*s.* 6*d.* net.

THE present volume is the first of a series on Economic Geology, to be issued under the general editorship of Dr. J. E. Marr, who remarks that the subject is "yearly receiving more attention in our great educational centres." This is gratifying, as the practical applications of knowledge must ever be one of the aims of those scientific workers who have at heart the welfare of mankind.

To instruct the mining student, the prospector, surveyor, and mine-manager on those questions which affect the occurrence of coal, is the main object of the book before us, and it is happily written by a geologist who has had a large experience in problems of coal and coal-mining, and who has spared no pains in the preparation of his work.

The publication comes at an opportune time, when, owing to the vast amount of coal that has already been raised from our principal coalfields, deeper sinkings in some of them and trial borings in unproved areas on their margins become more and more necessary.

Here, as pointed out by Dr. Gibson, intimate knowledge of the structure of each coalfield, and of the strata composing the coal-measures, is of the utmost importance. In many regions there are considerable thicknesses of red rocks that overlie the productive measures, in some cases conformably, in others with great discordance. The discrimination between these has not yet been satisfactorily made in all areas on our geological maps.

Moreover, the days are not over when black shales or lignite tempt the ignorant to fruitless enterprise, and we have known a deep and useless boring made in red rocks in an unpromising area, because it was thought from coal being worked under red rocks at Bristol it would be met with elsewhere under similar rocks at no great depth.

The information acquired in recent years of the horizons marked by certain fossil plants, mollusca, fishes and other organic remains has proved to be of considerable importance, at any rate locally. Thus a knowledge of the succession of rock-types in conjunction with the evidence of the fossils is of signal service in determining horizons in trial borings outside the exposed limits of a coalfield.

The author, from his personal experience, speaks guardedly about the testimony of the fossils: thus plants "are of service to the miner, only in a broad, general sense," whereas mollusca "in many coalfields fix the horizon of a particular bed." Much yet remains to be done, as we have yet to learn to what extent the vertical distribution of fossils in the Midland coal-basin holds good for other British coalfields. The fact, however, of their local importance should stimulate the interest of mine-managers, and induce them to collect and carefully record the horizons of fossils. The illustrations given of fossil plants are so excellent that they may well stir up enthusiasm.

While knowledge is required in the extension of workings beyond the limits of a coalfield, so also is it wanted in unknown areas. Coal-seams are very rarely exposed in cliffs and other natural sections, and even in trial borings they may be missed, because it is difficult with present contrivances to bring up good cores of coal, as it may be ground to powder.

An acquaintance with the characters of coal-bearing strata here comes to the help of the prospector, to whom the author gives much useful and judicious advice. Here also the occurrence of certain fossils may prove of ready assistance in negativing the prospect of coal or in encouraging enterprise.

The author gives brief accounts of the British coalfields and of those in various parts of the world. If he devotes more space to the Somerset and Gloucester coalfield than to that of South Staffordshire, it may be because in the latter the available quantity of coal that remains is estimated to be little more than one-third of that remaining in the Somerset and Gloucester area. The Yorkshire, Derbyshire, and Nottinghamshire coalfield "contains the largest reserve of coal in the British Isles"—*presumably*, we should add, for there are still large unproved areas in the south and east of England.

There is an ambiguity (on p. 44) where the author speaks of the chief coal-seams in the Southern Hemisphere and in India as belonging either to the Mesozoic or Tertiary period, because (on p. 46) he places the coalfields of South Africa, India, and Australia in the Palæozoic (Permian and Permo-Carboniferous).

We have left no space to refer to the many other matters of interest dealt with in this volume, such as the characters of coals and coal-seams, their origin and extent, the depth of mines, the faults and folds, and general structure of coalfields, illustrated by diagrams, but we may note that the map on p. 117 requires a further explanatory legend.

In all these matters above-mentioned, the author gives sound practical information, in which the doubts and difficulties and exceptions are very freely stated. In fact, one might conclude that with the increasing knowledge and importance of the subject a geological coal-mining expert must be a necessary officer in every coalfield.

REPORTS AND PROCEEDINGS.

I.—*May 6th*, 1908.—Professor W. J. Sollas, Sc.D., LL.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "Solution Valleys in the Glyme Area of Oxfordshire." By the Rev. E. C. Spicer, M.A., F.G.S.

A triangular area whose sides are defined by the converging Evenlode and Cherwell with a strike valley, containing the upper Swere for its base, contains a smaller triangular area defined by the confluent Glyme and Dorn. This area is part of the gently tilted Great Oolite limestone plateau, which is indented by a number of sunken valleys running in various directions, principally with a strike and dip trend, that show no marks of erosion but appear to be subsidence valleys. They begin suddenly at any part of the area, and descend with sinuous curves to a main valley into which they open quietly without disturbing the main valley's contour, and without bringing any surface débris. The main valley likewise enters a stream valley in a similar manner. The stream valley quietly develops into a broad sinuous river valley, with a floor, level in transverse section, over which a small river stream aimlessly meanders with the Evenlode characteristics. A gradation is shown from the plateau dry valleys to the meander valleys, which are sometimes flooded from bank to bank with soakage water. The plateau area is quite free from drift or gravels, and from any of the usual marks of surface denudation, although the valleys have strongly marked cross sections. There are no marks of marine currents, of fluvio-glacial scour, or of ice. There are no wind-gaps suggesting beheaded streams, nor any evidence of vanished heights that could produce torrents sufficiently strong to carve out the present surface. At the mouths of several of these dry winding valleys issue streams strongly impregnated with carbonate of lime. It is suggested that percolating water forming an underground course along joint lines removes enough material in solution to weaken a long, narrow, winding area over which the surface subsides until the underground stream is revealed. Solution then constantly widens the stream banks into bowls of soakage, and leaves insoluble material to build up a broad, level valley floor, which rises gradually above and obscures the dry valley outlet streams, these then forming marshes. It does not appear possible to reconstruct any local conditions that could have produced these valleys by mechanical erosion, and it is suggested that they are formed by underground solution, and are therefore called joint valleys or solution valleys. Prestwich (Quart. Journ. Geol. Soc., vol. xxviii, 1872, p. lxvii) estimates that 140 tons of carbonate of lime are annually removed from every square mile of the limestone area drained by the Thames. This would give an annual amount removed by solution from the small Glyme area of over 10,000 tons.

2. "On the Stratigraphy and Structure of the Tarnthal Mass (Tyrol)." By Alfred Prentice Young, Ph.D., F.G.S. With a "Note on two Cephalopods collected on the Tarnthal Köpfe (Tyrol)." By George C. Crick, Assoc.R.S.M., F.G.S.

The immediate occasion for this paper is the discovery of fossils which appear to throw new light on the relations of the rocks of this mountain. The rock series may be divided into three parts. (*a*) The lowest portion consists of dolomite, and the Lias is in normal position, the upper beds being the youngest: this portion is scarcely disturbed. (*b*) A middle section, consisting of calcareous schists, with a band of massive dolomite and dolomite breccia, shows marks of violent disturbance and crushing. (*c*) The uppermost part, a mass of more or less altered quartzite schists, calcareous schists, and serpentine, retains most of its original character and form, having undergone little mechanical distortion since it left its 'root.' The succession is summarized as follows:—

3. Serpentine.
   Ophicalcite.
   Tarnthal quartzites, etc.

2. Calcareous schists with green bands.
   Dolomite breccias.
   Calcareous schists.

1. Liassic limestone.
   'Principal dolomite' (Rhætic).

The explanation of the structure now suggested is as follows:—The line between 1 and 2 marks approximately the lower loop of a big fold, the dolomite breccia being a repetition in an attenuated form of the 'principal dolomite' below. The interpretation of the relations of 2 and 3 is not so clear. Either the whole series 2 and 3 is in inverted sequence, or else the dolomite breccia represents the whole of the 'principal dolomite' in a flattened fold (*nappe* of Termier), the serpentine and quartzite having been brought into their present position by a long overthrust, representing the *traineau écraseur* of the French geologists. The question whether the lower dolomite and the Lias are *in situ* or not is left undecided. A petrographical note is furnished on the amphibolite of Gutidamm.

II.—*May 20th*, 1908.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The President announced that the Daniel Pidgeon Fund for 1908 had been awarded to Mr. James Archibald Douglas, B.A., F.G.S., who proposes to investigate the zonal succession of the Lower Carboniferous rocks of Western Ireland.

The President read out the result of the poll taken to ascertain the opinion of the Fellows resident in the United Kingdom as to the admission of women to the Society, as follows:—

Papers sent out	879
Answers received	477

ANALYSIS OF REPLIES.

(1) Are you in favour of the admission of women to the Geological Society of London?

Yes	342
No	133
Not specified	2
	477

(2) Are you in favour of the admission of women as Fellows, or as Associates only? The 342 in favour of admission voted—

As Fellows	248
As Associates	84
Not specified	10
	342

(3) If there should not be a majority of those voting in favour of women as Fellows, are you in favour of their admission as Associates?

Yes	304
No	35
Not specified	3
	342
Add votes of those against the admission of women at all	133
And those who are neutral...	2
	477

The foregoing analysis shows that there were:

In favour of the admission of women as Fellows	248	
Against the admission of women as Fellows	217	133 against the admission of women at all. 84 in favour of the admission of women as Associates only.
Majority in favour of the admission of women as Fellows	31	

The following communications were read:—

1. "On some Fossil Fishes discovered by Professor Enjes de Souza in the Cretaceous Formation at Ilhéos, State of Bahia (Brazil)." By Arthur Smith Woodward, LL.D., F.R.S., F.L.S., V.P.G.S.

This paper proves that the Lower Cretaceous formation of Bahia extends along the coast to a point at least 130 miles south of the area previously described. The fish-remains are referable to new species of the genera *Mawsonia*, *Lepidotus*, and *Scombroclupea*. *Mawsonia* seems to have been scaleless, and differs from all known Jurassic and Cretaceous Coelacanth fishes in lacking denticles on the fins. The *Lepidotus* closely resembles the European Wealden *L. Mantelli* in proportions, but is more strongly ornamented. The *Scombroclupea* is peculiar, in exhibiting only scales where the anal finlets usually occur.

2. "The Bala and Llandovery Rocks of Glyn Ceiriog (North Wales)." By Dr. Theodore Groom, M.A., F.G.S., and Philip Lake, M.A., F.G.S.

In the district around Glyn Ceiriog, which the authors have mapped on the 6 inch scale, the following succession is given:—

Denbighshire Slates.	
Ty-Draw Slates, with *Monograptus Marri*	TARANNON and LLANDOVERY.
Fron-Frys Slates, with *Pentamerus undatus*, *Meristina* cf. *crassa*, *Nidulites favus*, etc.	

Glyn Valley Series.	(*b*) Glyn Grit and Limestone	Bala.
	(*a*) Ddolhir Beds, with *Phyllograpta Hisingeri*, *Ramipora Hoëstetteri*, *Trinucleus seticornis*, species of *Cybele*, *Chasmops*, *Remopleurides*, and numerous Cystids, Corals, Brachiopoda, etc. ...	
Graptolite Slates, with *Dicellograptus elegans*		
Gap.		
Pandy Series.	(*e*) Pen-y-Graig Ash	
	(*d*) Bryn Beds, with *Tetradella complicata*, *Phacops apiculatus*, *Trinucleus concentricus*, *Teiplesia spiriferoides*, *Rafinesquina ungula*, etc. ...	
	(*c*) Craig-y-Pandy Ash	
	(*b*) Teirw Beds, with *Lingula tenuigranulata*, *Bellerophon nodosus*, *Asaphus Powisi*, etc. ...	
	(*a*) Cwm-Clwyd Ash	

In the Pandy Series the beds *a*, *c*, and *e* consist essentially or wholly of ashes and tuffs (no lava-flows having been detected). Movements have often taken place along the two surfaces of the Craig-y-Pandy Ash, and the rock is commonly foliated, and locally converted into a white or blue china stone, in which good columnar jointing is sometimes shown. The authors have failed to detect any traces of thermometamorphic action of these bands on the adjoining slates, such as has been recently asserted. It is otherwise with an intrusive sill, which has been commonly mistaken for the uppermost ash.

The Teirw Beds are compared with the Roman Fell Group of the Lake District. The Bryn Beds agree most nearly with the Sleddale Beds of the same district.

The Graptolite Slates are separated from the underlying Pandy Series by the Ddolhir Fault, which has cut out a considerable part of the succession.

The Ddolhir Beds are extremely rich in fossils, which prove their equivalence with the Ashgillian formation of other districts. They appear to pass up into the Glyn Grit and Limestone, which is essentially a sandy and calcareous facies of the series. The Glyn Grit corresponds in position with the Corwen Grit; but, recognizing that it belongs to the Bala Series, the authors are no longer prepared, without further evidence, to assume the equivalence of the two grits.

The Fron-Frys Slates show the lithological characters of the Grey Slates of Corwen, but belong rather to the shelly than to the graptolitic facies of the Llandovery Series.

The Ty-Draw Slates resemble the pale Tarannon Slates of other districts. They appear to pass up into the Denbighshire Slates.

The authors find no indication of the overlap or overstep of the Wenlock, Tarannon, and Llandovery Beds mapped by the officers of the Geological Survey, or described by previous observers, although there is probably an unconformity at the base of the Fron-Frys Slates.

The beds of the district dip northwards at an almost uniformly low angle, but the structure is considerably complicated by a series of faults, most of which have hitherto escaped notice, some being very elusive. They include—(1) east and west faults, (2) north-north-west and south-south-east, or north and south faults, and (3) north-north-west and east-south-east faults.

Of the first series the most important is the Ddolhir Fault, which dips at an angle of 20°, nearly with the bedding, and may be either a thrust-plane or a lag-fault. Of the second series, the most remarkable is the Caemor Fault, on the east side of which the rocks have been raised nearly a mile, and shifted horizontally to the south for nearly three miles. Most of the remaining faults have a simple downthrow on the east.

III.—*June 3rd*, 1908.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The President announced that the Council had passed the following resolutions:—

"The Council of the Geological Society desires to express the profound regret with which it has heard of the death of Sir John Evans, K.C.B., F.R.S. Sir John Evans served the Society for many years in the Council, occupied the Presidential Chair from 1874 to 1876, being the Senior President living, and subsequently discharged the duties of Foreign Secretary for twelve years. Geological Science has gained much from the researches of Sir John Evans, and the place which he has occupied in the Society and the Council will be hard to fill."

"The Council also desires to express its regret at the loss of Professor Albert de Lapparent, who had been a Foreign Correspondent and Member of the Society since 1887, and who, as recently as last year, attended the celebration of the Society's Centenary and contributed not little to the proceedings on that occasion."

The President announced that, in accordance with a requisition "signed by five or more Fellows" of the Society (Byelaws, Sect. xi, Art. 4), a Special General Meeting would be held at the Society's Apartments on Wednesday, June 17th, 1908, at 7.45 p.m., in order to consider the following resolution, which would be proposed by Dr. J. Malcolm Maclaren and seconded by Mr. A. Gibb Maitland:—

"That Fellows non-resident in the United Kingdom be invited to express an opinion concerning the admission of women to Fellowship or Associateship of the Geological Society of London."

The following communication was read:—

"On the Fossiliferous Rocks of the Southern Half of the Tortworth Inlier." By Frederick Richard Cowper Reed, M.A., F.G.S., and Professor Sidney Hugh Reynolds, M.A., F.G.S.

This paper is a continuation of that on the igneous rocks of this area published in 1901 (Quart. Journ. Geol. Soc., vol. lvii, p. 267). The following succession is that adopted by the authors:—

		Thickness in feet.
Old Red Sandstone.		
Ludlow Rocks.		
Wenlock Rocks.	5. Fissile red and yellow sandstones with gritty and calcareous bands	?
	4. Upper limestone band ... ... about	25
	3. Variable non-calcareous beds, according to Phillips about	500
	2. Highly fossiliferous red clay or shale, with rubbly limestone and celestine band	12 (seen)
	1. Lower limestone band, somewhat sandy thickly bedded limestone	50
		625

Llandovery Rocks.	6.	Shales with grit and highly fossiliferous calcareous sandstone	?
	5.	Highly fossiliferous ashy limestone	2½ to 3½
	4.	Upper trap band ... ... about	60
	3.	Sandy limestone and calcareous sandstone and grit, crowded with fossils, about	500
	2.	Lower trap band ... maximum about	185
	1.	Micaceous sandstone, with *L. Sguonabi*	?
			800 to 850

The rocks are affected by the Hercynian flexures which produced the Bristol coal-basin, and the outcrop of the beds in the main follows the horseshoe-shaped outcrop of the Old Red Sandstone.[1] This regularity is lost at Daniel's Wood and Middlemill. Two important transverse faults traverse the outcrops, which are further obscured by the overlap of unconformable Trias. The trap-bands are found to be confined to the Llandovery, the number of recorded fossils has been largely added to, and previous statements as to the thinness and imperfect development of the Ludlow rocks and as to the probable exposure of the district to erosion in Ludlow and Lower Old Red Sandstone times are confirmed. The typical Ludlow fauna of Herefordshire and Shropshire has not been met with, and the series is clearly much attenuated. General remarks on the fossils are appended, and the paper contains lists of fossils in various collections (Bristol Museum, Sedgwick Museum, Earl Ducie's collection, and the Museum of Practical Geology, Jermyn Street), as well as those collected by the authors from the Llandovery and Wenlock formations.

CORRESPONDENCE.

CHANGES OF LEVEL AND RAISED BEACHES.

Sir,—I read with great interest Dr. Jamieson's paper on the above subject in the issue of the Geological Magazine for May (pp. 206–209).

I was, however, surprised to learn that Dr. Jamieson's views were expressed as original, for I laboured under the impression that they were long ago accepted by the majority of British geologists, and I have myself been teaching them for many years.

Professor Sollas ("The Age of the Earth," p. 35) clearly illustrates how such a state of affairs can take place, though not drawing specific attention to this as the cause of the phenomena of raised beaches.

Walter Baldwin.

Rochdale.
May 22nd, 1908.

THE MAMMALIAN FAUNA OF THE FOREST BED.

Sir,—In a cursory survey of fossil Voles,[2] chiefly from the so-called Forest Bed, I arrived at conclusions which in several respects are at variance with those of former writers on the subject. The

[1] Proc. Zool. Soc., 1902, p. 102.

supposed recent Voles of the Forest Bed I have come to consider as extinct species: the Pliocene Crag types, on the other hand, while entirely absent from the West Runton Fresh-water Bed, were found in the East Runton Forest Bed mixed with types of the former; this leads to the assumption that the Crag types have been washed into the East Runton deposit. The latter explanation, which I did not explicitly formulate at the time, receives strong support from the fact that at East Runton we find likewise a West Runton species of Beaver, together with a Pliocene species (*Castor plicidens*, Maj.), the inference to be drawn being that the provenance of the latter is the same as that of the Pliocene Voles, mingled at East Runton with the West Runton types.

If I am right in my deductions, it follows that the Vole fauna of the Forest Bed will, by the elimination of recent as well as of Pliocene types, prove to have been much more homogeneous than hitherto supposed. This being the case with one restricted group, it appears to call for a revision of all the other mammalian remains.

For many years I have entertained the suspicion that there must be something wrong with our lists of the Forest Bed Mammals. In plain language, the association of recent with Pliocene mammalian species, culminating in the assumption of the musk-ox having been a contemporary of the prototypes of the Upper Pliocene Val d'Arno fauna, is a faunistic impossibility. I therefore deny such an association of which there is no analogy in any other part of the world, although this has been assumed on erroneous determinations, e.g. with regard to the mammalian fauna of Leffe (Upper Lombardy).

I very much doubt whether in the end a single one of the supposed 24 recent species, out of a total of 45 Forest Bed Mammals, will remain, though in some cases it is not possible, for the present, to detect differences between a frigmentary fossil and the corresponding living species.

C. I. Forsyth Major.

AN *ORTHIS* FROM LADOCK QUARRY, CORNWALL.

Sir,—In the Memoirs of the Geological Survey, England and Wales, Explanation of Sheet 346, 1906, p. 35, the following paragraph occurs:—"A fossil has been found in the Ladock Quarry and placed in the Truro Museum. It is an *Orthis*, which Dr. Ivor Thomas, who examined it, thinks is probably new." The occurrence of a fossil in this quarry was so interesting and unlooked for that it seemed impossible to accept it without further evidence. Opportunity for investigation did not occur until April last, when I spent ten days with Mr. Upfield Green working over his promised section of the country between Newquay and Porthluney. The fossil in question was found by Bennett, a stonebreaker, on a pile of stones midway between Ladock and Grampound Road, and *not in the quarry at all*. He told me himself that his son broke the stone, and he noticed this fossil with the remains of several other impressions of shells. He preserved only this one specimen, which was an internal cast, and gave it to Mr. Minard, of Grampound, who afterwards deposited it in the Truro

Museum. The specimen has since been sent to London for examination, and casts were made for the British Museum and for Jermyn Street, as it was felt that the specimen might become of importance in future discussion. Bennett was positive in his assertion that the material on the stone heap came from Ladock Quarry, but Mr. J. O. Clemmow, of Ladock, who has been at some trouble in the matter, writes me as follows, under date 30th May, 1908:—"As a large quantity of stone from the South Coast, near the Helford River, has been brought into the immediate neighbourhood and broken for the roads, I should say that considerable doubt exists as to where the stone which produced this fossil was quarried."

The fossil seems to me to be the internal cast of a species of *Spirifer* of Taunusian age, and its appearance is suggestive of some southern locality, possibly the Looe area, and certainly not such as one would expect from the Ladock stone. A sharp look-out is now being kept for any trace of life from the Ladock Quarry, but the men working it have never seen a single shell. Nor has any sign of life ever been seen by either Mr. Upfield Green or myself in numerous visits, except some black flat grass-like markings, which Mr. Newell Arber would not venture even to call 'plant-remains.'

As the occurrence of this fossil has been so definitely given in print, it seemed worth while to investigate the story while those concerned in the statement were accessible, as endless trouble is occasioned by these records in after years when it is impossible either to prove or disprove them. C. Davies Sherborn.

A NOTE ON GRANITE AND A NOTE ON RIPPLEMARK.

Sir,—Since the appearance of my letter on granite in the March number of the Magazine, I have submitted to a physicist the drawings of inclusions in two Dartmoor rocks, which appeared in my paper in the Magazine in March, 1904. (Copies enclosed.) I sought to ascertain the significance of their disproportionate contents of chlorides and of water. This is the reply:—

"At the temperature when the water, with salt, etc., is above its critical point, the salt and water vapour would form a homogeneous mixture, and enclosures of this homogeneous mixture should show on cooling the same proportions of dissolved salt, crystallized salt, and liquid water."

The inference is that the enclosures referred to caught up their contents when the temperature was under the critical point of the salt and water, whatever that may exactly be. It would be higher, I am told, than that of plain water.

From the above it would appear that the chlorides of the western granites are as good records of the temperature of crystallisation as the carbonic acid inclusions of some other rocks.

To turn to a totally different subject, I should like to point out that in the paper by the late Dr. Sorby, just published in the Q.J.G.S., an incidental remark will clear up nearly sixty years of uncertainty. Dr. Sorby mentions that the depth of water in which he observed the

ripplemarks discussed in his classic paper, published in 1859 in the *Geologist*, was from one to eight inches. Hitherto Dr. Sorby's views could not be reconciled with the results obtained by other workers at much greater depths. We now know that there is no need to attempt to do so, and that Dr. Sorby's observations were accurate for the special case studied. He tells us that before he recorded his conclusions he had made 20,000 observations! The pity is that the results were compressed into ten pages of print.

A. R. Hunt.

THE KRAAI RIVER VERTEBRA REFERRED TO *EUSKELESAURUS*.

Sir,—Dr. A. Smith Woodward (Geol. Mag., June, 1908, p. 251) reprinted a paper on *Scaphonyx Fischeri*, which in 1907 was said to be a short-necked Dinosaur allied to *Euskelesaurus*. In a postscript (p. 255) it is remarked—"From new specimens submitted to me by Dr. I. C. White, I am now of opinion that *Scaphonyx* is an Anomodont." The publication of this evidence will be interesting, for the figured Brazilian bones, although very imperfect, make approximations to Saurischians, and show little in common with known Anomodonts.

Dr. A. Smith Woodward figured a cervical vertebra (Fig. 1, l.c., p. 252), and it is on this evidence that *Scaphonyx* was affiliated to *Euskelesaurus*, and compared with the cervical vertebra collected by myself and presented to the Natural History Museum. I do not see any close affinity between them. I was not quite certain of my own determination, and (Ann. Mag. Nat. Hist., Nov. 1894, p. 340) remarked upon the vertebra as "indicating, *if correctly referred*, that *Euskelesaurus* was a short-necked type." The determination therefore was questioned by myself when it was first made. This appears to have been overlooked, for Dr. A. S. Woodward says in his postscript—"The preceding paper was written in 1904, when Professor Seeley's determination of the cervical vertebra of *Euskelesaurus* had not been questioned." The paragraph continues—"Since that time Baron F. von Huene . . 1906 . . has expressed the opinion that the vertebra in question does not belong to a Dinosaur, but to an Anomodont." I am under the impression that I had mentioned verbally to v. Huene that I had ceased to refer the vertebra to *Euskelesaurus*, but the reference of it to an Anomodont is entirely his own. The interest of the quotation from the postscript is in Dr. A. Smith Woodward's conclusion that *Scaphonyx* is an Anomodont: for it would appear that he adopts v. Huene's conclusion concerning the Kraai River vertebra, from which I dissent.

In 1905 I deposited in the Natural History Museum for development, with a view to eventual presentation after description, a skeleton which I had known for ten years to be referable to the animal type from the Kraai River, which had been doubtfully referred to *Euskelesaurus*. In 1907 these bones were exhibited by me at a conversazione of the Royal Society under Dr. Broom's name, *Erythrosuchus Africanus*. The animal is not an Anomodont. In superintending the removal of the matrix, I took occasion to draw Dr. Smith Woodward's

attention to the identity of one of its cervical vertebræ with the vertebra from the Kraai River, and the label on the exhibited specimen, giving the name, was turned down at my request. My responsibility for reference of the specimen to *Euskelesaurus* ceased. There is no evidence for making the correction other than that in my possession and under description. Hence no publication seemed necessary in anticipation of final account of the animal.

In his postscript Dr. Smith Woodward states that "Dr. R. Broom has described similar vertebræ from the Upper Beaufort Beds of the Karoo Formation under the new generic name of *Erythrosuchus*." This scarcely represents the facts. If my new unpublished skeleton is omitted, there is no evidence to connect the Kraai River vertebra with Dr. Broom's types. Dr. Broom states that in *Erythrosuchus* "there is one well-preserved vertebra, which is either lower cervical or upper dorsal," compared to the dorsal vertebra of a carnivorous Dinosaur, and said to show that the rib was single-headed. On comparison of this vertebra (Ann. S. Afr. Mus., vol. v, pt. 4, figs. 8, 9) with the Kraai River fossil, it is difficult to recognise any near approximation. There is no room for doubt, for the Trustees of the South African Museum have given me, with the assistance of the Geological Department of the British Museum, the opportunity of studying Dr. Broom's *Erythrosuchus* in the description of my own materials.

Finally, the postscript remarks, "According to Dr. Broom's description this reptile is not a Dinosaur, but exhibits many resemblances both to Belodonts and to Anomodonts." Dr. Broom does not use the term Dinosauria, but refers his animal to the Phytosauria, because the ilium is like that of *Belodon*, and the other bones are said to be somewhat like; but he exhibits caution in not speculating on the nature of the skull. In 1892 (Quart. Journ. Geol. Soc., vol. xlviii, p. 189) I published the view that *Belodon* is a primitive Cetiosaurian, to be classed under the Saurischia. Therefore it makes little difference in my estimate of the wider ordinal affinities of the Kraai River fossil whether it is referred to the typical Saurischian *Euskelesaurus* or transferred to the subdivision Phytosauria and named *Erythrosuchus*. It is stated (Phil. Trans. Roy. Soc., 1892, pt. B, p. 346) that "Saurischian Dinosaur reptiles alone among Reptilia approximate towards the Anomodont types in pelvic characters," and I am not aware that these views have been elaborated by any subsequent writer, though I have repeatedly referred to the affinities of the two groups (l.c., p. 366; 1895, pt. B, pp. 41, 112, etc.).

H. G. Seeley.

CRETACEOUS[2] AND EOCENE DEPOSITS OFF THE SOUTH-WEST OF THE BRITISH ISLES.

Sir,—The publication of the remarkable papers by Mr. L. R. Crawshay and Mr. R. Hansford Worth, on the rocks dredged from the English Channel since 1906 (Journ. Marine Biol. Assoc., vol. viii, No. 2, May, 1908), marks a very distinct step forward in our knowledge of submarine stratigraphy. It seems of interest to state that the Cretaceous specimens therein recorded and illustrated are paralleled by

a considerable series of flints and chalk fragments recently dredged from about 500 fathoms off the Kerry coast by the Fishery Branch of the Department of Agriculture for Ireland. At two points, moreover, *Miliolina*-limestone has been found. This is at once distinguished from the specimens of Cretaceous Chalk by the naked eye, and it affords an unexpected extension of the material described by Mr. R. H. Worth from a dredging off the south of Cornwall. The Irish specimens will be dealt with in a forthcoming memoir of the Geological Survey of Ireland, in which Mr. T. Crook and myself have brought together what we know of the rocks forming the sea-bottom off the coast from Donegal to Kerry. The small part played in this area by ice-borne material agrees with the discoveries of Herr Bøggild off the coast of Greenland. We are now fortunate in having Mr. Worth's work for consultation and guidance, since it not only includes his previously published observations of 1899, but affords a valuable review of all rocks that have been recorded from the English Channel area.

Grenville A. J. Cole.

Geological Survey of Ireland,
14, Hume Street, Dublin.
June 13th, 1908.

OBITUARY.

ALBERT AUGUSTE DE LAPPARENT.

Born December 30, 1839. Died May 5, 1908.

It is with profound regret that we record the decease of M. de Lapparent, one of the most eminent geologists of France, who since 1875 has been Professor of Geology and Mining in the Catholic Institute at Paris. To geologists in this country he has been, perhaps, most widely known for his excellent "Traité de Géologie," of which the first edition was published in eight parts (1881–83), and the fifth edition in three volumes (1906). It is a work of great labour and research, and gives the best summary we have had of European geology, especially in the portions relating to stratigraphical palæontology.

Of other works, his "Cours de Minéralogie," published in 1884, reached its fourth edition during the present year; and mention should also be made of "Le Globe Terrestre," published in 1899. Interested largely in earth movements and earth sculpture, de Lapparent contributed original articles on these and other subjects to the Bulletin of the Geological Society of France, and he assisted in the preparation of the geological maps of La Manche and other areas.

A suave and fluent speaker, he was in much request at scientific gatherings, and his visits to this country at the time of the International Geological Congress in 1888 and during the recent centenary celebrations will be long remembered by those who had the privilege of listening to his eloquent speeches. He was elected a Foreign Member of the Geological Society of London in 1887.

SIR JOHN EVANS, K.C.B., D.C.L., F.R.S., F.G.S.,

A Trustee of the British Museum.

Born November 17, 1823. Died May 31, 1908.

We regret to announce the death of Sir John Evans, the distinguished antiquary and geologist, an account of whose life and labours in the cause of science we published, with a portrait, in the Geological Magazine for January, 1908 (pp. 1–10), together with a list of his writings. For some time past he had been suffering from an internal complaint, which became critical, necessitating an operation. He died on the 31st May in his 85th year. Sir John Evans was from 1864 a constant supporter of the Geological Magazine, to the pages of which he was also a frequent contributor.

CALEB BARLOW.

Born July 7, 1840. Died May 8, 1908.

Amongst those who in the latter part of the last and the beginning of the present century had been attached to the staff of the Geological Department, no one has left a more indelible record of long and excellent work performed than Caleb Barlow, the able formatore, developer, and modeller of extinct animals in the British Museum. Caleb Barlow, like Hugh Miller, was a mason and the son of a mason. He was born at Alton, Staffordshire, in the country of the New Red Sandstone, the Coal-measures, and the Carboniferous Limestone, where stone-quarrying or stone-cutting is the natural business of a large number of its inhabitants. Doubtless his early acquaintance with organic remains of various kinds in the rocks, as was the case with William Smith, Hugh Miller, and many others, led Barlow to take so great an interest in fossils in his later years.

He spent his youth and early manhood working at various places in Staffordshire and Shropshire, living for a year or two at Shifnal, and coming to London in 1864. Here he was engaged as a mason on several important public buildings, and was intimately associated with Mr. Henry Broadhurst, M.P. (who was also a working-mason), and Mr. Richard Hall, afterwards a co-worker with Barlow during twenty-eight years in the Geological Department.

C. Barlow entered the Geological Laboratory on November 16th, 1874, serving for five years at the old British Museum, Bloomsbury, prior to the removal to the new building in Cromwell Road, assisting during 1880, with Dr. Henry Woodward, Mr. William Davies, Mr. R. Etheridge, and Mr. R. B. Newton, in the task of removing the great collection of fossils to Cromwell Road, and with Richard Hall placing all the larger objects in the exhibition galleries ready for the opening in April, 1881.

It was largely due to the skill and knowledge previously acquired in moving of large and heavy stones that the great series of remains of extinct animals were safely and successfully transported to their present home. Some idea may be conceived of the work accomplished between June and October, 1880, when it is stated that the